

DIAGNOSTIC-FEASIBILITY STUDY

OF

Upper Echo Lake

FINAL REPORT

February 2002

Presented to:

County of Union

Division of Parks and Recreation

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Thanks is extended to all County employees who assisted in this study. Special gratitude is extended to Mr. Daniel Bernier for his invaluable perspective on all eleven study lakes and their surrounding watersheds and his diligent assistance throughout this study.

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Executive Summary

Overview

Upper Echo Lake is a 9.6 acre impoundment located in Echo Lake Park in the municipalities of Westfield and Mountainside. The Union County Park Commission created the lake in 1929. Amenities at Echo Lake Park include athletic fields, boating, fishing, ice skating, sledding, picnicking, a playground, and an outdoor lawn concert site.

Several problems are common to the county's waterways including degraded lake water quality, sedimentation, eroding shorelines, proliferation of nuisance weed growth and waterfowl, and inadequate public accessibility. Union County established a team to study and make recommendations for improvement to the County's waterbodies, including 30 lakes, ponds, and lagoons within the County park system, as well as three major rivers and their tributaries. Out of the 30 lakes, the Waterways Team prioritized the top twelve lakes in need of attention. Of the 12 priority lakes, Upper Echo Lake was given a high priority rating of # 3. The lake is in danger of losing a variety of uses due to excessive siltation, algae blooms and an overabundance of aquatic plants and waterfowl. Siltation has been a historic problem. The lake was created in 1929 and was spot dredged in 1953, 1960, 1971, 1972, 1976, and again in 1992.

In April 1996, Union County commissioned F. X. Browne, Inc. to perform a Phase I Diagnostic - Feasibility Study of Upper Echo Lake. The Diagnostic-Feasibility Study was conducted in two stages. The diagnostic portion of the study was conducted to determine current water quality conditions, identify existing problems, and determine the pollutant sources that are responsible for the observed problems. The feasibility aspect of the study evaluated a variety of lake and watershed management alternatives based on the results of the diagnostic study. The product of this study is a Diagnostic Feasibility Report that provides a recommended management plan for the restoration of Upper Echo Lake.

Conclusions

As part of the Upper Echo Lake Phase I Study, a lake and stream water quality monitoring program was conducted from May through August, 1996. Conclusions of the study are based on the diagnostic portion of the project.

Water Quality

- ! During most of the year, Upper Echo Lake is generally well mixed and oxygenated at all water depths.
- ! Under windless conditions in the summer months, the dissolved oxygen levels in the lake can be depleted and may have an adverse impact on the aquatic biota. Anoxic

(zero oxygen) conditions in the bottom waters of the lake can cause phosphorus to be released from the sediments into the water column, becoming available for algal growth.

- ! Phosphorus appears to be the "limiting" nutrient in Upper Echo Lake that causes the excessive algae and aquatic weed growth.
- ! The average total phosphorus concentration was 0.157 milligrams per liter (mg/L) and the average Secchi disk transparency measurement was 0.65 meters (2.1 feet). The average chlorophyll <u>a</u> concentration in the lake was 77.3 micrograms per liter (Fg/L). A lake with a total phosphorus concentration of 0.03 mg/L or greater is considered eutrophic. A lake with a Secchi disk transparency measurement of less than 2.0 meters (6.6 feet) is considered eutrophic, and a lake with a chlorophyll <u>a</u> concentration of greater than 10 Fg/L is considered eutrophic. Based on these parameters, Upper Echo Lake is classified as a highly productive or hyper-eutrophic lake.
- ! Upper Echo Lake has a very rapid flushing rate. This can be beneficial since pollutants may flush through the lake rather than settle and cause problems. It is estimated that the lake flushes 100 times per year or every 3.6 days.

Bathymetry and Sediment Chemistry

- ! The average water depth in Upper Echo Lake is 2.17 feet. The maximum water depth is 4.3 feet.
- ! Upper Echo Lake contains approximately 43,200 cubic yards of unconsolidated sediments. The average sediment thickness in the lake is 2.84 feet, and the maximum sediment thickness in the lake is 4.75 feet.
- ! Sediments in Upper Echo Lake contain benzo(a)pyrene in concentrations that exceed the acceptable level for residential and non-residential sediment disposal. Lead and benzo(a)anthracene exceed the acceptable level for residential sediment disposal. Therefore, the sediments in Upper Echo Lake are contaminated and disposal of these sediments will be difficult.

Macrophytes

! During the summer months, most of the surface area of Upper Echo Lake is choked by macrophytes (aquatic plants). The most dominant aquatic plants are duckweed and coontail.

Streams

- ! Two tributaries of the Nomahegan Creek feed directly into Upper Echo Lake.
- ! In general, the highest nutrient loadings, suspended solids loadings, and fecal coliform bacteria loadings to Upper Echo Lake are from lands which drain from the western portion of the watershed. Pollutant loadings are most likely due to commercial and residential land development.

Watershed Characteristics

- ! The ratio of the watershed area to lake surface area is 152:1. Implementing watershed management practices should have a positive impact on the water quality in Upper Echo Lake.
- ! The most dominant land use within the watershed area is medium density residential. Most of the commercial area is located adjacent to Route 22. Forested land is located in the northeastern portion of the watershed.
- ! Most of the land immediately adjacent to Upper Echo Lake is parkland consisting of grassed, open space area. The side of the lake opposite the boathouse/refectory is steep and forested.

Recommendations

Based on the diagnostic portion of the Upper Echo Lake Phase I Study, the following recommendations were developed as part of a Comprehensive Lake and Watershed Management Plan. The lake and watershed management plan focuses on increasing the water depth in the lake, improving the lake's fishery, and reducing nonpoint sources of pollution from the surrounding watershed.

Each element of the recommended Lake and Watershed Management Plan for Upper Echo Lake is described below.

Dredging

- ! Upper Echo Lake contains 43,200 cubic yards of unconsolidated sediment that should be removed by dredging. Sediments in Upper Echo Lake are contaminated with several types of pesticides and semi-volatile compounds.
- ! Upper Echo Lake should be mechanically dredged. The sediment must be disposed of in an approved disposal area, possibly on park property.
- ! Potential disposal areas for contaminated sediments include hazardous waste landfills and available non-residential land. County owned parkland may be acceptable for

sediment disposal, but site remediation techniques such as capping the sediments may be required. The DEP has indicated that they will consider disposal sites for contaminated sediments on a case by case basis. Currently, DEP has no specific guidelines for the disposal of contaminated sediments. Finding an acceptable disposal site for the sediments may be difficult, but according to DEP personnel, it is not impossible.

- ! A dredging feasibility study should be performed before detailed dredging design and permitting begins. The main work elements of the dredging feasibility study should include the following:
 - Attend a pre-application meeting with the DEP to discuss the project, to determine what permits will be required for this specific project, and to discuss potential disposal areas. A pre-application meeting is required by the DEP for dredging projects.
 - 2. Identify a suitable disposal area for the contaminated sediments. Suitable areas may include non-residential properties, including County property, or hazardous waste landfills.
 - Prepare a dredging feasibility report for submission to the County. Based on information provided in this report, Union County can determine if dredging Upper Echo Lake is feasible.
- ! The dredging feasibility study should also include an evaluation of beneficial soil reuse and reclamation of the contaminated sediments. This may be a difficult task due to the high concentration of semi-volatile compounds in the sediments.

Lake Aeration

! Lake aeration is not recommended at the present time. If lake dredging occurs, lake aeration should be reevaluated if dissolved oxygen levels in the lake still remain low.

Batch Alum Treatment

! Batch alum treatment may be a feasible restoration option for Upper Echo Lake. This option should be further investigated by conducting bench tests to determine application rates of alum. This option typically works by adding alum to the water. The alum combines with the phosphorus in the water column and settles to the bottom of

the lake. Therefore, the phosphorus in the water column is significantly reduced and algal populations are reduced.

Watershed Investigations

As part of this study, limited watershed investigations were conducted to identify specific nonpoint source pollution problem areas. However, a more comprehensive study is necessary in order to locate specific problem areas within the watershed.

The following steps should be taken to complete a more detailed watershed investigation:

- ! Identify specific nonpoint source problem areas. Areas to be investigated should include, but not be limited to, streambanks, culverts, roadways, roadway stream crossings, storm drainage pipes, parking lots, and areas of excessive stormwater runoff.
- ! Once problem areas have been identified, they should be prioritized.
- ! The problem areas should be analyzed in order of priority for possible retrofit controls, or best management practices (BMPs). Possible retrofit controls may include constructed wetlands, erosion control, stormwater diversion, and modification of fertilization and mowing procedures.

The watershed investigations should be coordinated by Union County. The initial investigations can be performed by volunteers. The prioritization of nonpoint source problem areas and the evaluation of retrofit opportunities, however, should be performed by professionals.

Shoreline Stabilization

Severely eroded areas along the lake shoreline should be stabilized.

- ! The shoreline between the boathouse/refectory and the dam is a heavy traffic area and should be stabilized with structural measures such as gabions or riprap to allow access to the lake and at the same time prevent further shoreline erosion. If a more natural shoreline is desired at this location, erosion control matting with vegetation can be used for stabilization. However, the vegetation cannot be mowed to the edge of the lake.
- ! The shoreline between the lake inlet and the boat house/refectory should be stabilized with bioengineering techniques including coir fiber bundles and selected vegetation

to provide a natural setting in this area and to enhance wildlife habitat. Landscaping with vegetation and woody shrubs to control geese populations is encouraged in this area.

Streambank Stabilization

Severely eroded streambanks of the inlet streams should be stabilized.

- ! Approximately 250 linear feet of streambank along the smaller inlet stream to Upper Echo Lake is eroded and should be stabilized with bioengineering techniques.
- ! Approximately 2600 linear feet of streambank along the larger tributary of Upper Echo Lake is eroded and should be stabilized with a combination of bioengineering techniques and structural methods.

Waterfowl Control

- ! Canada geese populations at Upper Echo Lake are excessive and should be controlled. Geese droppings are a significant and direct source of phosphorus, nitrogen and bacteria to Upper Echo Lake.
- ! Geese populations should be controlled by landscaping, egg inactivation, chemical deterrents, culling during summer molt, and scare tactics.
- ! Park visitors should be discouraged from feeding the geese and other waterfowl. Signs should be posted at strategic locations in the park to inform people about not feeding the waterfowl.
- ! An ordinance to prohibit feeding of waterfowl is recommended. The ordinance should include provisions for enforcement.

Urban Stormwater Management

- ! Union County and local municipalities should evaluate street sweeping schedules. Increased street sweeping is recommended, especially in the spring and summer months.
- ! Stormwater catch basins should be cleaned after major storm events or at least once every three months. Cooperation between Union County, the local municipalities, and the New Jersey Department of Transportation is recommended for this task.
- ! Although most of the watershed is developed, every opportunity to improve stormwater quality should be taken. For example, if a commercial establishment changes

ownership, and the new owner needs approvals from the local municipality, local ordinances should be in place to require improving stormwater runoff quality from the site before approvals are granted. Possible stormwater quality treatment systems that could be installed on a developed property include sand filters, peat filters, or bioretention systems. The purpose of these systems is to treat stormwater runoff from roads and parking lots. These systems are installed to treat the first 0.5 inches of stormwater runoff. The first 0.5 inches of runoff is called the "first flush" and typically contains the highest concentration of pollutants from a storm event.

! Existing homeowners and business owners should be encouraged to direct roof runoff to dry pits or rain barrels to reduce the amount of stormwater that enters the storm sewer system. Using a rain barrel or cistern gives the homeowner the advantage of water use reduction by storing rain water to water gardens or lawns during dry periods.

Riparian Corridor Management

! Two tributaries enter Upper Echo Lake. A large portion of these tributaries are piped, underground systems. However, there are sections of the tributaries that are open, natural channels. These stream corridor areas should be preserved. Since these sections of the streams are located within the Upper Echo Lake Park, Union County should maintain the stream corridors in their present condition. Eroded areas of the streambanks should be stabilized as described above. A 75-foot buffer should be maintained along the entire stream channel. Willows and other trees should be planted along the smaller inlet stream to stabilize the soil, intercept and treat stormwater runoff, modify stream temperature, and provide valuable habitat for wildlife.

Homeowner Practices

Homeowner practices should be implemented as part of the public education program described in the following section.

- ! Lawn fertilizer can be a significant source of nutrients to lakes, especially in suburban areas where nice green lawns are desirable. A fact sheet on the importance of proper lawn fertilization should be prepared and distributed to homeowners in the watershed. This task could be facilitated through the public education program described below or by an "extra" in the local newspaper. Fact sheets could be posted at the park and possibly at local businesses.
- ! Homeowners should be encouraged to maintain appropriate vegetation on their property to control runoff.
- ! Leaf management is also important in reducing nonpoint source pollution in a developed watershed. The existing leaf management program should be evaluated to determine if there are ways to improve the program so that leaves do not end up in the

street for a long period of time. If leaves are left in the street too long, nutrients leach from the leaves and are carried into the storm sewers and eventually into the lake with stormwater runoff. Bagging leaves in biodegradable bags is one possibility for improving the leaf management program.

- ! Homeowners should be informed that if they dump household chemicals and other substances into storm sewers, these substances will end up in the lake. Stenciling should be painted on storm inlets to educate homeowners that anything that goes down the storm sewer eventually drains to the lake.
- ! Homeowners should be encouraged to wash cars and trucks on grassy areas, if possible. This practice will reduce the amount of phosphorus and detergents that runs down the driveway, into a nearby storm sewer, and eventually into Upper Echo Lake. Another alternative is to use a commercial car wash.

Public Education Program

Union County is continuing to develop and implement an extensive environmental education program throughout the County. The County's environmental education program should be integrated into the Upper Echo Lake watershed project. The environmental education program for Upper Echo Lake should include the following elements:

- 1. Develop and distribute nonpoint source brochure,
- 2. Develop a watershed management curriculum for presentation to local schools.
- 3. Develop and install an educational kiosk at Upper Echo Park
- 4. Write fact sheet on watershed management for distribution at the kiosk and at park events, and
- 5. The satellite operation of Trailside Nature and Science Center being developed by the County for location in Warinanco Park should include staffing to conduct watershed management education programs.

Water Quality Monitoring Program

! A limited water quality monitoring program should be implemented, after dredging has been completed, to document water quality improvements. Yearly monitoring of selected parameters (i.e. total phosphorus, total nitrogen, chlorophyll <u>a</u>, and Secchi disk depth) should be conducted to document water quality changes in the lake.

Fish Stocking

! Fish stocking is recommended only after watershed management practices have been implemented, and a suitable fish species diversity study has been completed in order to ensure optimum survival rates for the introduced fish.

<u>Institutional Approaches</u>

- ! The Union County Waterways Team should work closely with Township officials to improve the water quality in Upper Echo Lake and to implement this Watershed Management Plan.
- ! The Union County Waterways Team and local municipalities should evaluate existing subdivision ordinances, erosion and sedimentation control ordinances, stormwater management ordinances, and other existing ordinances to look for ways to strengthen these ordinances to protect the water quality in Upper Echo Lake.



1.0 Project Description

1.1 Introduction

In the early 1920's, Union County Sheriff James E. Warner had a dream to save the Rahway River from overdevelopment and pollution. Echo Lake Park was established in 1925 as a part of the Union County Park Commission's vision to see the Sheriff's dream become reality. Echo Lake Park, and 26 other parks that today comprise 5000 acres of park land in Union County, was the result of years of hard work and political activism on the part of Union County Park Commissioners and dedicated volunteers. The land around Echo Lake was chosen to become a park because of its centralized location, easy accessibility, the wooded valley that kept its picturesque waters hidden from the nearby urban centers. Upper Echo Lake was created in 1929 by the installation of a dam that flooded the upper valley. A scenic drive was added in 1929, as well, and 10,000 cubic yards of silt were removed in 1953. The lake is enjoyed today, as it was in the early days, for boating, fishing, picnicking, swimming and ice skating.

1.2 Background

In 1995, the County of Union established a "Waterways Team" which has the primary objective of developing a strategic plan to improve the County's waterways. The Waterways Team, consisting of ten County staff employees and a municipal watershed inspector, initially set its sights on dealing with 30 or more lakes, ponds, and lagoons that are County-owned and located in the County's vast park system. More recently, the team has also begun to examine problems along the County's rivers and streams, most notably the Rahway River, which Upper Echo Lake drains to.

The most common lake problems noted by the Waterways Team are degraded water quality, accumulation of litter, debris, and sediments, eroding shorelines, proliferation of nuisance weed growth, overabundance of waterfowl, degraded dam structures, and poor accessibility for the public.

The Waterways Team has determined the 12 most critical lakes in the Union County Park System. The team used a priority ranking system to evaluate the overall degradation of County-owned lakes. One of these lakes, Lake Surprise, was studied by F. X. Browne, Inc. (1995). The Lake Surprise Phase I Diagnostic-Feasibility Study was conducted in accordance with CFR, Part 35, Subpart H entitled "Cooperative Agreements for Protecting and Restoring Publicly Owned Freshwater Lakes" which pertains to the federal Clean Lakes Program. Based on qualifications and the success of the Lake Surprise Phase I Study, Union County also retained F. X. Browne, Inc. to implement the Lake Surprise Phase II Restoration Project. The major components of the Lake Surprise Phase II Restoration Project are the removal of excessive accumulated sediments in the lake, the design and implementation of watershed

best management practices, the development of an environmental education curriculum, and the implementation of a post-dredging water quality monitoring program.

The eleven remaining critical lakes, as ranked by the Waterways Team from most to least degraded, are Green Brook Park Lagoon, **Upper Echo Lake**, Seeley's Pond, Rahway River Park Lake, Warinanco Park Lake and Lagoon, Milton Lake, Meisel Pond, Lower Echo Lake, Nomahegan Lake, Briant Pond, and Cedar Brook Park Lake. The locations of the above eleven lakes are shown in Figure 1.1.

In an effort to restore these lakes as natural, recreational, and aesthetic resources, the Union County Division of Parks and Recreation retained F. X. Browne, Inc. to perform Diagnostic-Feasibility Studies for these remaining eleven critical lakes. The Phase I Diagnostic-Feasibility Studies have been performed by using a modified monitoring program that generally meets the requirements in 40 CFR, Part 35, Subpart H entitled "Cooperative Agreements for Protecting and Restoring Publicly Owned Freshwater Lakes".

Based on the recommended comprehensive management plans offered as part of the Phase I Diagnostic-Feasibility Studies, Union County will then implement the recommended lake and watershed restoration strategies as capital appropriations and operating funds become available. Union County also will use these studies to apply for various sources of state and federal funding.

Individual reports were prepared for each of the eleven Union County study lakes. This document represents the Phase I Diagnostic - Feasibility Report for Upper Echo Lake. Upper Echo Lake is located in Echo Lake Park. This county-owned park is located in the central portion of Union County as shown in Figure 1.1.

Figure 1.1 Location of the Eleven Union County Study Lakes	
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1.3 Project Objectives

The Diagnostic-Feasibility Studies for all eleven study lakes were conducted in two stages. The diagnostic portion of the studies was conducted to determine current water quality conditions, identify existing problems, and determine the pollutant sources that are responsible for the observed problems. The feasibility aspect of the studies evaluated a variety of lake and watershed restoration alternatives based on the results of the diagnostic study. These alternatives included watershed management practices and in-lake restoration methods. The management plan resulting from the feasibility study includes a description of identified lake and watershed problems, proposed solutions, and a suggested implementation program.

The primary objectives of the Phase I Diagnostic-Feasibility Studies for all eleven County-owned study lakes were:

- To evaluate the existing water quality conditions in eleven study lakes and to determine the impacts on the recreational uses of these lakes and their surrounding areas,
- 2. To identify the sources and magnitude of pollutants entering the eleven study lakes,
- 3. To evaluate feasible control alternatives and restoration methods, and
- 4. To develop and recommend conceptual lake and watershed management plans that are cost-effective, environmentally sound, acceptable to the public, and can be used as the basis for Phase II Implementation Grant Applications for submission to the U.S. Environmental Protection Agency (U.S. EPA) and other government agencies.

2.0 Lake and Watershed Characteristics

2.1 Lake Morphology

Upper Echo Lake is a 9.6-acre impoundment located in the southeastern portion of Echo Lake Park, in Mountainside and Westfield, New Jersey. Upper Echo Lake is fed by two tributaries of the Nomahegan Creek as well as by springs. The watershed of Upper Echo Lake is 1460 acres, including the area of the lake. The watershed boundary is shown in Figure 2.1 and includes Echo Lake Park, medium density residential areas, commercial areas located along Route 22, and forested areas located in the Watchung Reservation.

A complete listing of morphometric and hydrologic characteristics of Upper Echo Lake are summarized in Table 2.1.

Table 2.1 Morphometric and Hydrologic Characteristics of Upper Echo Lake				
Lake Surface Area	9.6 acres			
Lake Volume	6.1 Million Gallons			
Average Depth	2.17 feet			
Maximum Depth	4.3 feet			
Hydraulic Retention Time	3.6 days			
Average Discharge	2.64 cfs			
Drainage Basin Area (excluding lake area)	1450.4 acres			

Figure 2.1 Watershed Area Map of Upper Echo Lake	
Unner Echo Lake Watershed Management Plan	Page 6

2.2 Benefits and Recreational Uses of Upper Echo Lake

2.2.1 Present Uses

Upper Echo Lake is the most easily accessible and heavily used of three lakes located in Echo Lake Park, Union County, New Jersey. The park is owned and maintained by Union County and is open to the public. The lake is a recreational focal point for the park. It is presently used for fishing and boating.

In addition to Echo Lake Park, there are other parks in the area offering a variety of recreational activities to the general public, including Echo Lake Country Club, Watchung Reservation, Lenape Park, Nomahegan Park, Rahway River Parkway, and Galloping Hill Golf Course. The proximity of these other recreational areas to Echo Lake Park make it part of a very significant "green space corridor". Considering the population density of the area, Upper Echo Lake is an important recreational, economic, and ecologic resource.

2.2.2 Impairment of Recreational Uses

Upper Echo Lake is currently used for fishing and boating; however, these uses are becoming threatened due to siltation, algae growth, and increasing waterfowl and aquatic plant populations. If steps are not taken to improve the water quality in Upper Echo Lake soon, boating will not be possible due to shallow water and dense weed populations. Boating has already been restricted from the upstream end of the lake.

2.3 Lake Bathymetry

A bathymetric survey was conducted by F. X. Browne, Inc. in September 1996. Water and sediment depth measurements were collected along 12 transects. From these measurements, water depth and sediment thickness maps were prepared and are shown as Figures 2.2 and 2.3, respectively. The water depth map was used to determine the lake's volume, average depth, maximum depth and hydraulic retention time as presented in Table 2.1. Based on the sediment thickness mapping, Upper Echo Lake contains 43,200 cubic yards of unconsolidated sediments. The average sediment thickness is 2.84 feet, and the maximum sediment thickness is 4.75 feet.

Figure 2.2 Bathymetric Map of Upper Echo Lake	
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Figure 2.3 Sediment Thickness Map of Upper Echo Lake	
Linnar Echa Lako Watershad Management Plan	Page 0

2.4 Watershed Characteristics

The Upper Echo Lake watershed covers 1460 acres, including the 9.6 acre lake. Therefore, the ratio of the watershed area to the lake surface area is 151:1. This ratio is relatively high, but a combination of watershed management activities such as erosion control and stormwater management, and in-lake restoration techniques should effectively reduce the sediments and nutrients entering Upper Echo Lake and improve water quality. Approximately 25 percent of the Upper Echo Lake watershed area lies within Echo Lake Park.

Union County, and therefore the Upper Echo Lake watershed, lies entirely in the Piedmont Plains sub-province of Northern New Jersey. Comprising about one-fifth of the total area of New Jersey, the Piedmont Plains sub-province extends southwestward from the Hudson River, between the Coastal Providence and Highlands sub-province, with an extension continuing further south (into Alabama and Georgia), between the Blue Ridge Mountains and the older Appalachians.

Topographically, the Piedmont Plains sub-province includes ridges, hills, and higher elevations rising as much as 400 feet above adjoining lands. This sub-province is primarily a lowland of smooth, rounded hills separated by wide valleys sloping gently down to the Coastal Plain with no clear topographic distinction between these two divisions.

2.4.1 Topography

The Upper Echo Lake watershed area is rectangular in shape as shown in Figure 2.1. The lake itself is located just east of the Watchung Mountains, which are generally oriented in a northeast to southwest direction. Lands in Union County east of the mountains are gently sloping plains that eventually become areas of tidal marsh land bordering the Arthur Kill and Newark Bay. Upper Echo Lake is located on sloping plains. Portions of the park and watershed have slopes ranging from 2 percent to greater than 15 percent. The land immediately surrounding the lake is in the 2 percent to 7 percent slope range.

2.4.2 Geology

Glacial activity has influenced the majority of the subsurface geology in Northern Jersey. Though influenced by glaciers, no significant glacial surface deposits, such as stratified drift, ground moraine, or terminal moraine, are found within the Upper Echo Lake watershed area.

Most of the Upper Echo Lake watershed area consists of shale and sandstone of the Brunswick Formation, and much of the area is a glacial "outwash plain" covered to varying depths with sand, silt, gravel, and cobbles in well-defined layers or beds deposited by water from melting glaciers.

2.4.3 Soils

The majority of the soils in Union County belong to the major Gray-Brown Podzolic soil grouping indigenous to the northeastern United States. These soils developed beneath the hardwood forest are common along the eastern coast. Soils derived from soft red shale and sandstone (Brunswick Formation) make up most of Union County. The major soil series of the watershed area is the Boonton soils series. The soils within the watershed are moderately erosive.

2.4.4 Land Use

Land uses in the Upper Echo Lake watershed area are presented in Table 2.2. Land use data were determined from topographic maps by planimetry. Field investigations were used to verify existing land uses delineated from topographic maps.

Table 2.2 Land Use in the Upper Echo Lake Watershed Area					
Land Use Category	Area (acres)	Percent (%)			
Forest	147	10			
Open Space (parkland)	360	25			
Residential	935.4	63.8			
Commercial	8	0.5			
Upper Echo Lake	9.6	0.7			
Total (including Upper Echo Lake)	1460	100			

2.5 Population and Socio-Economic Structure

Upper Echo Lake is located within the Echo Lake Park, which is one of 26 parks operated by the Union County Division of Parks and Recreation. Upper Echo Lake, along with lands within the park, provide a variety of recreational opportunities for the residents of Union County and other nearby counties. The park is located within the New York City Metropolitan Region.

In addition to Upper Echo Lake and its watershed, many people visit several other county parks and other attractions that are located in the area. The park is part of a significant green space corridor for a very densely populated area and region.

Union County is one of twenty-one counties in the State of New Jersey. Union County comprises an area of 103.4 square miles which makes it the smallest county in the state. The county consists of 21 municipalities: 5 cities, 8 townships, 7 boroughs and 1 town.

Population data for Union County are presented in Table 2.3. The population of Union County was 504,094 in 1980, 493,819 residents in 1990, and 522,541 in 2000. The population reduction from 1980 to 1990 is attributed to the lack of available vacant land for development and a decline in birth rate. The greatest growth rate in Union County occurred in the decades following World War I and II. The population increased by 5.8% from 1990 to 2000.

Table 2.3 Population Data for Union County, New Jersey					
	Population				
County	1980	1990	2000		
Union County	504,094	493,819	522,541		

Source: Union County Data Book, 1991, U.S. Census, 2000.

The population density of Union County was 5,073 persons per square mile in 2000, making it the third most densely populated county in the state (New Jersey Department of Labor). The distribution of people by race in 2000 in Union County was 65.5 percent white, 20.8 percent black, and 10.4 percent for other minorities. People of Hispanic origin comprised 19.7 percent of the county's population in 2000.

Union County ranks as one of the more affluent counties in the State of New Jersey. According to the 1980 census, the median family income was \$25,266 compared to \$22,907 for the state. In 2000, the median family income in Union County was \$50,254. Based on 2000 census data, only 9.3 percent of the county reported incomes below the poverty level as compared to 9.3 percent for the state.

3.0 Monitoring Program

3.1 Primer on Lake Ecology

[Refer to Appendix A for a comprehensive list of Lake and Watershed Management Terms]

Lake water quality is a direct reflection of the water quality of the watershed area. The term "watershed area" is defined as all lands that eventually drain or flow into a lake (... "all waters that are shed to a lake"). Potential sources of water to lakes are streams (tributaries), surface runoff (overland flow from lakeside properties), groundwater (interflow), and precipitation. The water quality of these sources are greatly influenced by watershed characteristics including soils, geology, vegetation, topography, climate, and land use. Typical land uses encountered in watershed areas are wetlands, forests, agriculture, residential, commercial, and industrial. With regards to water quantity, larger watershed areas contribute larger volumes of water to lakes and vice versa.

Nutrients (nitrogen and phosphorus) and suspended solids enter a lake from upstream tributaries, direct overland flow (runoff from adjacent lands) and storm drains that collect runoff from the roadside areas adjacent to the lake. Nutrients can also enter a lake as shallow groundwater flow and direct precipitation. As surface waters enter a lake, water velocity decreases and allows for suspended solids to settle to the bottom of the lake (i.e. "sedimentation"). Very small sediment particles, such as clays, resist sedimentation and may pass through the lake without settling. Suspended solids generally contain attached phosphorus which is commonly referred to as "particulate phosphorus". Consequently, lakes provide an excellent environment for the sedimentation of suspended solids along with attached forms of phosphorus.

Within a lake, water quality is largely affected by a complex system of chemical, physical and biological interactions. Phytoplankton (suspended microscopic algae) and macrophytes (aquatic plants) adsorb available nutrients and convert them into plant material. The most readily-available form of phosphorus is dissolved orthophosphate, analytically determined as dissolved reactive phosphorus (DRP). DRP can include other forms of phosphorus such as hydrolyzable particulate and organic phosphorus, but these concentrations are generally considered negligible in lakes. The inorganic forms of nitrogen, ammonia (NH₃-N) and nitrate (NO₃-N), are the forms most available to support the growth of aquatic life. Macrophytes and algae can also affect concentrations of other chemicals in the water. For example, in the photosynthetic process, carbon dioxide, a weak acid, is removed from the water and oxygen is produced. This process results in increased pH and dissolved oxygen levels.

Interactions among biological communities (the food web) greatly affect levels and cycling of nutrients, such as phosphorus, nitrogen and carbon in lakes. Energy from the sun is captured and converted to chemical energy via photosynthesis in aquatic plants, which forms the base of the food web as shown in Figure 3.1. Energy and nutrients, now tied up in organic

molecules, travel through the different levels of the food web. Small aquatic animals (zooplankton and invertebrates) graze upon algae and plants. Larger invertebrates and fish then consume the grazers. Energy at upper levels of the food web is derived from the breakdown of organic molecules in the process known as respiration. Respiration and decomposition processes consume oxygen in the water column and in lake sediments.

The organic waste products of these aquatic organisms along with their remains after death are called "detritus". Detritus settles to the bottom of the lake and becomes part of the sediment. Bacteria and fungi (decomposers) use the energy in the detritus thereby converting organic materials into inorganic nutrients which are once again available for use by plants and algae. Unused organic material accumulates in the sediments. Energy can become blocked in lower levels of the food web instead of flowing smoothly through it, because many of the algae and aquatic plants found in highly eutrophic lakes are also the ones least favored by grazers.

3.2 Study Design and Data Acquisition

Lake water quality samples were collected monthly from May through August, 1996. In general, lake studies are performed during the growing season (May through August) in order to assess the ecological health of the lakes. The growing season is typically the critical period for most lake systems. During the summer months, lake usage by the public sharply increases and lake problems (if any) are most prevalent (algae blooms, floating mats of algae, dense plant growth, noxious odors, and fish kills).

Stream water quality and discharge data was used to assess the nutrient and sediment budgets and overall impacts that major streams had on the study lakes. Of the eleven study lakes, only five lakes have major tributaries. Milton Lake, Seeley's Pond, and Nomahegan Lake are fed by a single tributary, while Briant Pond and Upper Echo Lake are fed by two major streams. The remainder of the study lakes are primarily fed by surface runoff and groundwater sources.

Sediment samples were collected from the study lakes for physical and chemical analysis. Bathymetric and macrophytic surveys of all eleven study lakes were perforned as discussed in Section 2.3 and 3.10 of this report.

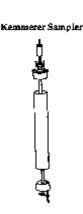
The results of the water quality monitoring program for Upper Echo Lake are summarized below. For more detailed information about these monitoring programs, refer to the "Union County Eleven Lakes Quality Assurance/Quality Control Work Plan" that was prepared by F. X. Browne, Inc. (1996).

Figure 3.1	The Aquatic Food Web	
Upper Ech	no Lako Watershad Management Plan	Page 15

Lake Water Quality Monitoring

One lake water quality monitoring station, Station UEL1, was established in Upper Echo Lake

at the deepest portion of the lake, located near the dam. On each study date, lake water samples were collected using a vertical Kemmerer sampler (Model 1290, Wildlife Supply Company) at depths of 0.5 meters below the lake's surface and 0.5 meters above the lake's bottom. The discrete top and bottom lake water samples were subsequently composited together and analyzed for nutrients (total phosphorus, dissolved reactive phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and ammonia nitrogen), and total suspended solids. The pH of the composited sample was measured in the field using a portable pH meter (Model pHep3, Hanna Instruments).



On each study date, temperature and dissolved oxygen profiles were measured every 0.5 meters using a dissolved oxygen and temperature meter. The Secchi disk transparency was also measured using an 8-inch diameter black and white Secchi disk.

Additional lake samples were collected monthly for chlorophyll <u>a</u> analysis and for phytoplankton and zooplankton identification and enumeration (to genus). A minimum of two discrete lake water samples were collected from the photic zone using a vertical Kemmerer water sampler. The photic zone was defined in this study as a water depth equal to two times the Secchi disk depth. Photic zone discrete samples were then composited together and analyzed for chlorophyll <u>a</u> and used for phytoplankton identification and enumeration. Zooplankton samples were collected by vertically towing a plankton net (80 Fm mesh size with a 8-inch orifice) at least five times through the water column. Both phytoplankton and zooplankton identification and enumeration were performed in the laboratory using a Sedgewick-Rafter counting chamber and a microscope equipped with a Whipple Grid. All phytoplanton and zooplankton cell densities (number per volume) were expressed as biomass based on mean cell size.

Major Tributaries

Two major tributaries to Upper Echo Lake were monitored under baseflow (low flow) and stormflow (high flow) conditions. Discrete baseflow stream sample collection coincided with the lake monitoring study dates, while discrete stormflow stream samples were collected during three different storm events.

Both samples were analyzed for total suspended solids, total phosphorus, total Kjeldahl nitrogen (TKN), nitrate-nitrite nitrogen, ammonia nitrogen, and pH (in the field).

During stream sample collection, the stream flow was measured using methods approved by the United States Geological Survey (USGS). Stream flows were determined by measuring the water depths and the water velocities along pre-determined stream cross-sectional areas. Stream velocity and water depth measurements were collected by using a Global Flow Probe (Global Water Instruments) stream velocity meter.

Sediment Sampling

Three discrete sediment core samples were collected from Upper Echo Lake using a Ogeechee lake sediment sampler (Model 2427, Wildlife Supply Company) equipped with 20 inch corer tubes. Discrete sediment samples were collected along the center line of the lake near the middle and at both ends. Discrete sediment samples were subsequently composited together in the field and submitted to the laboratory for analysis.

The composited lake sediment sample was analyzed for particle size distribution, solids, total phosphorus, total nitrogen, polychlorinated biphenyls (PCBs), pesticides, heavy metals, organic compounds, chlorides, pH, and reactivity for sulfur and cyanide (total concentrations only).

Bathymetric and Macrophyte Surveys

A bathymetric survey and macrophyte survey of Upper Echo Lake were conducted in September 1996. The bathymetric survey involved taking measurements of water depth and sediment depth along pre-determined transects in the lake. The macrophyte survey involved collecting, identifying, and delineating aquatic plants in order to show the distribution within the lake.

Based on the above information, a bathymetric map, an unconsolidated sediment depth map, and a macrophyte map were prepared (see figures 2.2, 2.3, and 3.2, respectively).

3.3 Lake Water Quality

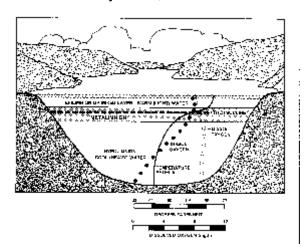
Lake water quality samples were analyzed for a variety of chemical, physical and biological parameters. The results of these analyses are discussed in detail in the following sections of this report and water quality data are presented in Appendix B.

3.3.1 Temperature and Dissolved Oxygen

In late spring or the beginning of summer, deep temperate lakes develop stratified layers of water, with warmer water near the lake's surface (epilimnion) and colder water near the lake's bottom (hypolimnion). As the temperature difference becomes greater between these two water layers, the resistance to mixing increases. Under these circumstances, the epilimnion (top water) is usually oxygen-rich due to photosynthesis and direct inputs from the atmosphere,

while the hypolimnion (bottom water) may become depleted of oxygen due to oxygen being consumed by organisms decomposing organic matter at the lake bottom.

Conversely, shallow temperate lakes may never develop stratified layers of water. For these shallow lake systems, wave action caused by the wind may be sufficient to keep the entire



lake completely mixed for most of the year. In shallow lakes, low dissolved oxygen levels may occur above the lake sediments even though most of the water in the lake is completely mixed.

Therefore, both shallow and deep temperate lakes can have low dissolved oxygen concentrations near the surface of the lake sediments. If low dissolved oxygen levels occur near the lake bottom, sediments may release significant amounts of nutrients (primarily orthophosphorus and ammonium) back into the lake, thereby allowing for more nutrients for algae and aquatic plant growth.

During the study period, Upper Echo Lake was thermally unstratified and is considered a completely mixed lake system during the summer months. The dissolved oxygen and temperature profiles in Upper Echo Lake in August 1996 are listed in Table 3.1. The maximum depth at the monitoring station was 1.0 meters (m) or 3.3 feet. The water temperature ranged from 25.0 degrees Celsius (° C) (77°F) at a depth of 1 meter to 27.5°C (81.5°F) near the surface of the lake. Dissolved oxygen concentrations ranged from 9.0 milligrams per liter (mg/L) at a depth of 1 meter to 11.2 mg/L near the surface of the lake. Dissolved oxygen and temperature profiles for the May, June and July sampling events were similar to profiles measured in August. During all sampling events, the dissolved oxygen concentration remained well above zero in the bottom waters.

Table 3.1 Dissolved Oxygen and Temperature Profile Data Upper Echo Lake - August 1996				
Depth (meters)	Temperature (Celsius)	Dissolved Oxygen (mg/L)		
0.0	27.5 (81.5°F)	11.2		
0.5	26.5 (79.7°F)	12.8		
1.0	25.0 (77.0°F)	9.0		

In general, the optimal water temperature for trout is 55 to 60 EF (12.8 to 15.6 EC). Trout may withstand water temperatures above 80 EF (26.7 EC) for several hours, but if water temperatures exceed 75 EF (23.9 EC) for extended periods, trout mortality is expected (Pennsylvania State University). A safe minimum dissolved oxygen concentration for trout is 5 mg/L. Warmwater species (i.e. golden shiners, bass, bluegill) which are more typical of New Jersey lakes grow well when water temperatures exceed 80 EF (26.7 EC). For many warm water fish species, 3 mg/L is considered to be a safe minimum dissolved oxygen concentration. Upper Echo Lake is too warm and the dissolved oxygen concentration is too low for coldwater fish, such as trout; however, the lake can support warmwater fish species.

3.3.2 pH

In lake ecosystems, changes in pH occur when phytoplankton use carbon dioxide during photosynthesis. Dissolved carbon dioxide reacts with water to form carbonic acid (H₂CO₃). When phytoplankton take up the carbon dioxide dissolved in the lake water during photosynthesis, the result is a decrease in the carbonic acid concentration and a consequent increase in pH. For this reason, the pH of surface waters is higher during an algal bloom than the pH of deeper waters where phytoplankton (suspended microscopic plants) numbers are much lower.

Acidic water contains a relatively high concentration of hydrogen ions, and the higher the concentration of hydrogen ions, the lower the pH. Several anionic salts such as bicarbonates, carbonates, phosphates, silicates, and borates, can bind with hydrogen ions, thereby reducing the acidity of water. When these salts bind with the hydrogen ions, the pH increases and the water is said to be "buffered".

The pH values in Upper Echo Lake ranged from 7.6 to 9.1 standard units (su), with a mean pH value of 8.2 standard units. The water in Upper Echo Lake is considered basic (0.6 to 2.1 standard units above neutral conditions). Under most circumstances, pH values for lakes in the United States generally range between 6.0 and 9.0 standard units.

3.3.3 Total Suspended Solids

The concentration of total suspended solids in a lake is a measure of the amount of particulate matter in the water column. Suspended solids are comprised of both organic matter (i.e. algae) and inorganic materials (i.e. soils and clay particles).

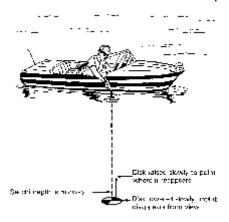
The total suspended solids concentration in Upper Echo Lake ranged from 4.0 to 15.3 mg/L, with a mean of 10.4 mg/L. The mean total suspended solids concentration in the lake is considered high for most lake and reservoir systems.

3.3.4 Transparency

The transparency, or clarity, of water is most often reported in lakes as the Secchi disk depth. This measurement is taken by lowering a circular white or black-and-white disk, 20 cm (8 inches) in diameter, into the water until it is no longer visible. Observed Secchi disk depths

range from a few centimeters in very turbid lakes to over 40 meters in the clearest known lakes (Wetzel, 1975). Although somewhat simplistic and subjective, this testing method probably best represents the conditions which are most readily visible to the common lake user.

Secchi disk transparency is related to the transmission of light in water and depends on both the absorption and scattering of light. The absorption of light in darkcolored waters reduces light transmission. Light scattering is usually a more important factor than



absorption in determining Secchi depths. Scattering can be caused by color, by particulate organic matter, including algal cells, and by inorganic materials such as suspended clay particles in water.

In Upper Echo Lake, Secchi disk transparency readings ranged from 0.5 to 1.0 meters (1.6 to 3.3 feet) with a mean Secchi disk measurement of 0.65 meters (2.1 feet). Based on criteria established by the United States Environmental Protection Agency (U.S. EPA 1980), Secchi disk readings that are less than 1.5 meters indicate eutrophic (highly productive) conditions. Upper Echo Lake is highly eutrophic (hyper-eutrophic) based on the EPA criterion for Secchi Disk depth.

3.3.5 Phosphorus Concentrations

Phosphorus and nitrogen compounds are major nutrients required for the growth of algae and macrophytes in lakes. The dissolved reactive phosphorus, nitrate nitrogen, and ammonia nitrogen are regarded as the dissolved inorganic nutrient forms most readily available to support aquatic growth, while the total nutrient amounts provide an indication of the maximum growth which could be achieved in the lake. In most lake systems, phosphorus is the limiting nutrient and therefore is the nutrient which controls the amount of aquatic plant growth (vascular plants and algae).

Total phosphorus represents the sum of all forms of phosphorus, and includes dissolved and particulate organic phosphates from algae and other organisms, inorganic particulate phosphorus from soil particles and other solids, polyphosphates from detergents, and dissolved orthophosphates. Soluble orthophosphate is the phosphorus form that is most readily available for algal uptake and is usually reported as dissolved reactive phosphorus, because the analysis takes place under acid conditions which can result in some hydrolysis of other phosphorus forms. Total phosphorus levels are strongly affected by the daily

phosphorus loads that enter the lake. Soluble orthophosphate levels, however, are affected by algal consumption during the growing season.

The total phosphorus concentrations in Upper Echo Lake ranged from 0.081 to 0.234 mg/L as P with a mean of 0.157 mg/L, as phosphorus (P), The dissolved reactive phosphorus ranged from 0.008 to 0.022 mg/L as P, with a mean of 0.016 mg/L as phosphorus (P). The phosphorous concentrations are shown in Table 3.2.

Table 3.2 Mean Phosphorus Concentrations in Upper Echo Lake		
Total Phosphorus (mg/L as P) Dissolved Reactive Phosphorus (mg/L as P)		
0.157 [0.081 - 0.234]	0.016 [0.008 - 0.022]	

Note: Range of concentrations present inside of brackets [].

The dissolved reactive phosphorus is considered to be the phosphorus that is readily available for algae and macrophytes to use. In many lake systems during the summer months, dissolved reactive phosphorus concentrations are very low (less than 0.001 mg/L) since it is readily used by plants and algae as soon as it becomes available. The mean total phosphorus concentration in the lake of 0.157 mg/L is typical of eutrophic lake conditions. Based on criteria set forth by the U.S. EPA, a lake system is classified as eutrophic when total phosphorus concentrations exceed 0.03 mg/L as P.

3.3.6 Nitrogen

Nitrogen compounds are also important for algae and aquatic macrophyte growth. The common inorganic forms of nitrogen in water are nitrate (NO₃-), nitrite (NO₂-), and ammonia (NH₃). The form of inorganic nitrogen present depends largely on dissolved oxygen concentrations. Nitrate is the form usually found in surface waters, while ammonia is only stable under anaerobic (low oxygen) conditions. Nitrite is an intermediate form of nitrogen which is unstable in surface waters. Nitrate and nitrite (total oxidized nitrogen) are often analyzed together and reported as NO₃+NO₂-N, although nitrite concentrations are usually insignificant. Total Kjeldahl nitrogen (TKN) concentrations include ammonia and organic nitrogen (both soluble and particulate forms). Organic nitrogen is easily determined by subtracting ammonia nitrogen from total Kjeldahl nitrogen. Total nitrogen is easily calculated by summing the nitrate-nitrite, ammonia, and organic nitrogen fractions together.

The mean total nitrogen concentration, organic nitrogen concentration, nitrate plus nitrite nitrogen concentration, and ammonia nitrogen concentration in Upper Echo Lake, are presented in Table 3.3.

Table 3.3 Mean Nitrogen Concentrations in Upper Echo Lake				
Total Nitrogen (mg/L as N) Organic Nitrogen (mg/L as N) Nitrate/Nitrite Ammonia (mg/L as N)				
2.29 [0.94 - 4.89]	1.74 [0.28 - 4.11]	0.46 [0.11 - 0.68]	0.10 [0.10 - 0.10]	

Note: Range of concentrations present inside of brackets [].

In Upper Echo Lake the total nitrogen is 2.3 mg/L. Of this total nitrogen, most of nitrogen occurs in the organic form. Nitrate/nitrite plus ammonia concentrations (inorganic nitrogen compounds) in the lake are 0.56 mg/L, which indicate high uptake rates by aquatic plants and algae for growth and reproduction.

3.3.7 Limiting Nutrient

Algal growth depends on a variety of nutrients including macronutrients such as phosphorus, nitrogen, and carbon, and trace nutrients such as iron, manganese, and other minerals. According to Liebig's Law of the Minimum, biological growth is limited by the substance that is present in the minimum quantity with respect to the needs of the organism. Nitrogen and phosphorus are usually the nutrients limiting algal growth in most natural waters.

Depending on the species, algae require approximately 15 to 26 atoms of nitrogen for every atom of phosphorus. This ratio converts to 7 to 12 mg of nitrogen per 1 mg of phosphorus on a mass basis. A ratio of total nitrogen to total phosphorus of 15:1 is generally regarded as the dividing point between nitrogen and phosphorus limitation (U.S. EPA, 1980). Identification of the limiting nutrient becomes more certain as the total nitrogen to total phosphorus ratio moves farther away from the dividing point, with ratios of 10:1 or less providing a strong indication of nitrogen limitation and ratios of 20:1 or more strongly indicating phosphorus limitation.

Inorganic nutrient concentrations may provide a better indication of the limiting nutrient because the inorganic nutrients are the forms directly available for algal growth. Ratios of total

inorganic nitrogen (TIN = ammonia, nitrate, and nitrite) to dissolved reactive phosphorus (DRP) greater than 12 are indicative of phosphorus limitation, ratios of TIN:DRP less than 8 are indicative of nitrogen limitation, and TIN:DRP ratios between 8 and 12 indicate either nutrient can be limiting (Weiss, 1976).

The total nitrogen to total phosphorus ratio (TN:TP) and the total inorganic nitrogen to dissolved reactive phosphorus ratio (TIN:DRP) in Upper Echo Lake were 13.7:1 and 35.3:1, respectively. Based on these nutrient ratios, the limiting nutrient in the lake appears to be phosphorus.

3.3.8 Chlorophyll a

Chlorophyll \underline{a} is a pigment which gives plants their green color. Its function is to convert sunlight to chemical energy in the process of photosynthesis. Because chlorophyll \underline{a} constitutes about 1 to 2 percent of the dry weight of planktonic algae, the amount of chlorophyll \underline{a} in a water sample is an indicator of phytoplankton biomass.

The chlorophyll <u>a</u> concentrations in Upper Echo Lake ranged from 16.5 to 141.4 micrograms per liter (Fg/L), with a mean concentration of 77.3 Fg/L. Based on USEPA criteria, a lake is classified as eutrophic when chlorophyll <u>a</u> concentrations exceed 6.0 to 10.0 Fg/L. Therefore, Upper Echo Lake is highly eutrophic based on chlorophyll <u>a</u> concentrations. In addition, the lake was treated with algicides during the study period so chlorophyll <u>a</u> concentrations measured during the study period are even lower than would be expected.

3.3.9 Phytoplankton

Phytoplankton are microscopic algae that have little or no resistance to currents and live free floating and suspended in open water. Their forms may be unicellular, colonial, or filamentous. As photosynthetic organisms (primary producers), phytoplankton form the foundation of the aquatic food web and are grazed upon by zooplankton (microscopic animals) and herbivorous fish (plant-eating fish).

A healthy lake should support a diverse assemblage of phytoplankton represented by a variety of algal species. Excessive phytoplanktonic growth, which typically consists of a few dominant species, is undesirable. Excessive growth can result in severe oxygen depletion in the water at night, when the algae are respiring (using up oxygen) and not photosynthesizing (producing oxygen). Oxygen depletion can also occur after an algal bloom when bacteria grow and multiply using dead algal cells as a food source. Excessive growths of some species of algae, particularly members of the blue-green group, may cause taste and odor problems, release toxic substances to the water, or give the water an unattractive green soupy or scummy appearance.

Planktonic productivity is commonly expressed by enumeration and biomass. Enumeration of phytoplankton is expressed as cells per milliliter (cells/mL). Biomass is expressed on a mass per volume basis as micrograms per liter (mg/L). Of the two, biomass provides a better estimate of the actual standing crop of phytoplankton in lakes.

Upper Echo Lake was chemically treated with an algicide during the sampling period; therefore, phytoplankton biomass measured during this period is lower than would be expected. During the study period, five taxa (groups) of phytoplankton were identified in Upper Echo Lake including Bacillariophyta (diatoms), Chlorophyta (green algae), Chrysophyta (golden brown algae), Cryptophyta (cryptomonads), and Pyrrhophyta (dinoflagellates). The phytoplanktonic total biomass ranged from 4,218 to 33,098 micrograms per liter (ug/L) with a mean biomass of 20,275 ug/L, which is relatively high. However, there are no generally accepted standards for phytoplankton biomass. The lowest total biomass levels were observed in the month of May and the highest total biomass levels were observed in July.

Another indication of eutrophication is the dominance of blue-green algae (Cyanophyta) in lakes; however, since algicides were applied to Upper Echo Lake, no blue-green algae were observed during the sampling period. If algicides were not applied to this lake, it is likely that blue-green algae would be present in large numbers.

3.3.10 Zooplankton

Zooplankton are microscopic animals whose movements in a lake are primarily dependent upon water currents. Zooplankton remain suspended in open water. Major groups of zooplankton include protozoa, rotifers and

crustaceans. Crustaceans are further divided into copepods and cladocerans (i.e. water fleas). Zooplankters are generally smaller than 2 millimeters (one-tenth of an inch) in size and primarily feed on algae, other zooplankton, and plant and animal particles. Zooplankton grazing can have a significant impact on phytoplankton species composition and productivity (i.e. biomass) through selective grazing (e.g. size of zooplankton influences what size phytoplankton are consumed) and nutrient recycling. Zooplankton, in turn, are consumed by fish, waterfowl, aquatic insects, and others, thereby playing a vital role in the transfer of energy from phytoplankton to higher trophic levels.

In Upper Echo Lake, the zooplankton biomass ranged from 38.5 to 1615 Fg/L, with a mean of 2,410 Fg/L. The lowest biomass levels were observed in May and the highest levels were observed in June. In general, the zooplankton biomass order of dominance in Upper Echo Lake was copepods followed by rotifers, cladoceras, and protozoans.

Zooplankton data are often used in conjunction with fishery surveys to assess a lake's fishery. In particular, the mean length of crustacean zooplankters collected during the spring and mid-

summer is compared to one another and the results can be used to assess a lake's fishery (Mills and Green, 1987). In Upper Echo Lake, the mean length of crustacean zooplankton ranged from 0.43 millimeters (mm) in June to 0.54 mm in May.

These mean zooplankton lengths in early-spring and summer are quite small and are typical of lakes with low predator to prey ratios. Under such circumstances, a lake's fishery can consist of many undersized planktivorous fish (i.e. blue gill, white perch, yellow perch, pumpkinseed). With too many undersized planktivorous fish and too few piscivorous fish (i.e. bass, pickerel) to control them, overgrazing of large-bodied zooplankters is inevitable. If the zooplankton population is low, the algae population is high because there are not enough zooplankton to eat and control the algae population.

Based on the zooplankton data, Upper Echo Lake most likely contains an unbalanced fishery. An unbalanced fishery may be caused by the over-harvesting of larger gamefish by anglers or indirectly related to poor lake water quality. Poor lake water quality may severely impair reproductive success rates, growth rates, and survival rates of some gamefish.

3.3.11 Trophic State Index

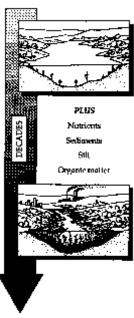
Eutrophication is a natural process where sediments and nutrients from the watershed accumulate in the lake. The eutrophication process is often accelerated by the activities of people. Contrary to popular opinion, a eutrophic lake is not "dead;" it is actually suffering from

an over-abundance of living organisms. The organisms in a eutrophic lake are excessive in number, but usually represent relatively few species. In contrast, an oligotrophic lake contains relatively small numbers of organisms representing many species. Mesotrophic lakes have intermediate conditions between eutrophic and oligotrophic lakes.

The Trophic State Index (TSI) developed by Carlson (1977) is among the most commonly used indicators of lake trophic state. This Carlosn TSI is actually composed of three separate indices based on total phosphorus concentrations, chlorophyll <u>a</u> concentrations, and Secchi disk depths for a variety of lakes. Total phosphorus is an important parameter because phosphorus is often the limiting nutrient for algal growth in lakes. Chlorophyll <u>a</u> is a plant pigment present in all algae and is used to express indirectly the biomass of algae in a lake. Secchi disk depth, as discussed previously, is a common measure of the transparency of the water in a lake.

Summer average values for total phosphorus, chlorophyll <u>a</u>, and Secchi depth are logarithmically converted to a scale of relative trophic state ranging from 1 to 100. Increasing values for the Trophic State Index are indicative of

Accelerated Entrophication



increasing trophic state in a lake. In general, index values less than 40 are indicative of oligotrophic conditions, while index values greater than 50 are indicative of eutrophic lake conditions.

The mean Carlson Trophic State Index (TSI) values for Upper Echo Lake were 77 for total phosphorus, 73 for chlorophyll-a, and 66 for Secchi disk transparency. Based on the mean TSI values, Upper Echo Lake is classified as a highly productive or hyper-eutrophic lake.

3.4 Macrophytes

Aquatic vegetation ranges from tiny microscopic algae or phytoplankton to large vascular aquatic plants which are called macrophytes. Macrophytes can be found rooted to the lake bottom or floating on the lake's surface. Based on growth and habitat characteristics, macrophytes generally can be classified in one of three categories: submerged aquatic vegetation, floating aquatic vegetation, and emergent aquatic vegetation. Submerged aquatic plants live and grow completely underwater or just up to the surface of the water. A few submerged species protrude just above the water surface when in flower. Floating aquatic plants refers to those plants whose leaves float on the surface of the water. These plants may or may not be anchored to the bottom of the lake via stems or roots. Emergent aquatic plants have their upper stems and leaves protruding above the surface of the water. These plants are always attached directly to the lake bottom via root systems.

A macrophyte survey of Upper Echo Lake was conducted in September 1996. Plants were collected, identified to genus, and mapped to show the distribution within the lake. The distribution of macrophytes in Upper Echo Lake is illustrated in Figure 3.2.

The aquatic plant community in Upper Echo Lake primarily consisted of Coontail (*Ceratophyllum demersum*) and Duckweed (*Lemna sp.*). Less dominant types of macrophytes included common rush, marsh purslane, and slender pondweed. In general, the density of macrophytes in Upper Echo Lake are considered excessive and have already begun to negatively impact lake uses.

Figure 3.2 Macrophyte Map of Upper Echo Lake			

3.5 Water Quality Comparison of Union County Lakes

Water quality comparisons of the eleven study lakes are based on a trophic state ranking system as shown in Table 3.4. This ranking system assigned point values to the Carlson's Trophic State Index (TSI) values for total phosphorus, chlorophyll <u>a</u>, and Secchi disk transparency for each study lake. Next, the point values for the three parameters were added together for each lake and these total point values provided the basis for lake water quality data comparisons as described below.

For all three parameters (total phosphorus, chlorophyll-a, and Secchi disk transparency), lake TSI values received scores ranging from 1 to 11 points. For example, the lake with the highest TSI value for phosphorus (worst water quality) received 1 point, while the lake with the lowest TSI value for phosphorus (best water quality) received 11 points as shown in Table 3.4. This scoring procedure was also performed for both chlorophyll-a and Secchi disk transparency TSI values. Next, for each study lake, the "Individual TSI Ranked Scores" for all three parameters were summed, thereby resulting in a "Total TSI Ranked Score". Based on this scoring procedure, the "Total TSI Ranked Scores" could theoretically range from 3 to 33 points. Using the "Total TSI Scores", the eleven study lakes were subsequently ranked relative to one another (Relative Ranking) from lowest (worst water quality) to highest (best water quality) as shown in Table 3.4.

In Table 3.4, the Total TSI Ranked Scores for the eleven study lakes ranged from 7 to 33 points. Of these County lakes, Warinanco Park Lake and Seeley's Pond recorded the poorest and best lake water quality, respectively. It should be noted that the majority of the study lakes were treated with algicides throughout the study period, therefore the TSI values for Secchi disk transparency and chlorophyll-a data and subsequently their Total TSI Ranked Scores are likely "artificially" lower than expected. Of the study lakes, only Briant Park Pond and Seeley's Pond were not chemically treated with algicides during the study period.

Based on the data presented in Table 3.4, Upper Echo Lake was ranked the ninth, meaning that eight of the study lakes had poorer water quality than did Upper Echo Lake. Only Milton Lake and Seeley's Pond had better water quality than did Upper Echo Lake. As stated above, Upper Echo Lake was treated with algicides during the study period; therefore, its ranking may be higher than expected.

Table 3.4

Lake Water Quality Data Comparisons Using Carlson's Trophic State Index Values

		TSI Values		Algici des	Total TSI	Relative
Lake Name	Total P	Secchi Disk	Chlorophyll-a	Used	Ranked Score	Ranking
Warinanco Park Lake (WPL)	91 [2]	76 [2]	75 [3]	Yes	7	1
Cedar Brook Park Lake (CBPL)	80 [7]	76 [1]	77 [2]	Yes	10	2
Briant Park Pond (BPP)	82 [6]	73 [4]	81 [1]	No	11	3
Green Brook Park Lagoon (GBPL)	97 [1]	74 [3]	66 [9]	Yes	13	4
Nomahegan Park Lake (NPL)	87 [4]	71 [6]	74 [6]	Yes	16	5
Lower Echo Lake (LEL)	90 [3]	61 [10]	75 [4]	Yes	17	6
Meisel Pond (MP)	83 [5]	73 [5]	71 [8]	Yes	18	7
Rahway River Park Lake (RRPL)	76 [10]	69 [7]	74 [5]	Yes	22	8
Upper Echo Lake (UEL)	77 [9]	66 [8]	73 [7]	Yes	24	9
Milton Lake (ML)	79 [8]	62 [9]	63 [10]	Yes	27	10
Seeley's Pond (SP)	61 [11]	59 [11]	49 [11]	No	33	11

Note: Values in brackets [] are the "Individual TSI Ranked Scores" for total phosphorus, Secchi disk transparency, and chlorophyll-a for each lake.

3.6 Lake Water Quality Summary

Based upon the results of the monitoring program including total phosphorus, chlorophyll a, Secchi disk transparency, and Carlson's Trophic State Index, Upper Echo Lake is classified as a completely mixed eutrophic lake system. The limiting nutrient in the lake appears to be phosphorus.

3.7 Lake Sediment Analyses

As part of a lake study, lake sediments are often collected and analyzed for nutrients, texture, and accumulated pollutants, such as pesticides, herbicides, and metals. Sediment test results are used to assess the potential impacts of any accumulated pollutants on the aquatic community, investigate the internal release of nutrients by in-lake sediments, and determine how to properly dispose of lake sediments during a lake dredging project.

In September 1996, one composited lake sediment sample was collected and analyzed for particle size distribution, solids (total, volatile and percent composition), nutrients (total phosphorus, total nitrogen), heavy metals, pesticides, polychlorinated biphenyl compounds, herbicides, volatile organic compounds, and semi-volatile compounds. With the exception of particle size and solids data, the above data were analyzed as total (bulk) concentrations and are presented on a dry weight basis.

The physical characteristics of the sediments in Upper Echo Lake are presented in Table 3.5. Based on weight, the sediments in Upper Echo Lake contain 47.5 percent water and 52.5 percent solids. Of these solids, the lake sediments are primarily composed of inorganic materials. Based on particle size, most of the solids are classified as silt as shown in Table 3.5.

Table 3.5 Physical Characteristics of Sediments in Upper Echo Lake			
Parameters Results			
Composition:			
Percent Solids	52.5		
Particle Size Distribution:			
Percent Gravel	9		
Percent Sand	5		
Percent Silt	61		
Percent Clay	25		
Total	100		

With regard to sediment disposal and sediment reuse, the sediment analyses should meet the Soil Cleanup Criteria proposed by the New Jersey Department of Environmental Protection (NJDEP). Sediment reuse, such as fill material, is obviously the least expensive manner in which to dispose of dredged lake sediments. Under the Soil Cleanup Criteria, one set of criteria applies to the disposal of sediments at residential type lands, while the second set of criteria applies to the disposal of sediments at non-residential type lands. Of the two sets of criteria, the residential criteria are more stringent.

Both sets of criteria list a variety of pollutants along with their corresponding proposed state regulatory levels. These pollutants are classified as heavy metals, polychlorinated biphenyl compounds (PCBs), pesticides, herbicides, volatile organic compounds (VOCs), and semi-volatile organic compounds (SOVs). The proposed regulatory levels are based on total concentrations and are expressed on a dry weight basis.

The hazardous constituents in the composited sediment sample collected from Upper Echo Lake were compared to the NJDEP proposed Soil Cleanup Criteria for both residential and non-residential land classifications. The total concentrations of the above parameters that exceeded the residential or both the residential and non-residential Soil Cleanup Criteria proposed by NJDEP are presented in Table 3.6. All sediment quality data are presented in Appendix C.

Table 3.6 Total Concentrations of Various Constituents Exceeding the Proposed NJDEP Soil Cleanup Criteria

Parameter	Measured Concentration (mg/Kg)	Residential Criteria (mg/Kg)	Non-Residential Criteria (mg/Kg)
Metals			
Lead	162	100	600
Semi-volatile Compounds			
Benzo(a)anthracene	1.3	0.9	4
Benzo(a)pyrene	1.5	0.66	0.66

In Upper Echo Lake, lead, benzo(a)anthracene and benzo(a)pyrene exceeded the Soil Cleanup Criteria proposed by the NJDEP as shown in Table 3.6. These contaminants are coal tar products which most likely enter the lake via asphalt from roadways and parking lots. Lead and benzo(a)anthracene exceed the residential criteria, while benzo(a)pyrene exceeded both the residential and non-residential criteria. Disposal of these sediments will be more difficult and costly than disposal of uncontaminated sediment. The contaminated sediment can either be capped with clean soil or the sediment can be transported to a hazardous waste landfill.

All proposed lake dredging projects are reviewed by the NJDEP on a case-by-case basis. As stated previously, the NJDEP Soil Cleanup Criteria are informal guidelines that have not been promulgated by the State of New Jersey as formal regulatory levels.

3.8 Stream Water Quality

During the Eleven Lakes Phase I Study, the water quality of all major tributaries (streams) was monitored. The two major tributaries of Upper Echo Lake were monitored during May through September 1996.

Water quality samples were collected four times during baseflow (low flow) conditions and three times during stormflow (high flow) conditions. All stream water quality samples were collected as discrete samples as described in Section 3.2. Stream water quality samples

were analyzed for total suspended solids, total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate plus nitrite nitrogen, and pH (in the field). Total Nitrogen concentrations were determined by summing the total Kjeldahl nitrogen and nitrate plus nitrite concentrations together.

Baseflow and stormflow stream water quality data are presented in Table 3.7 and Appendix D. In general, the amount of nutrients and suspended solids to Upper Echo Lake dramatically increased during storm events. High stormflow concentrations in streams indicate that nonpoint sources of pollution to Upper Echo Lake are likely significant.

Table 3.7 Mean Total Phosphorus, Total Nitrogen, and Total Suspended Solids in Major Tributaries				
Total Phosphorus Total Nitrogen Total Suspended Station (mg/L as P) (mg/L as N) Solids (mg/L)				
Baseflow				
UELT1	0.042 [0.033-0.050]	2.01 [1.80-2.22]	1.2 [1.0-1.6]	
UELT2	0.167 [0.088-0.394]	1.95 [1.23-2.50]	5.6 [1.2-11.2]	
Stormflow				
UELT1	0.123 [0.064-0.156]	3.53 [2.27-5.51]	2.9 [2.0-4.4]	
UELT2	0.167 [0.116-0.201]	2.63[2.48-2.89]	9.5 [5.2-17.2]	

Note: Range of concentrations presented in brackets []

4.0 Pollutant Budgets

4.1 Overview

Pollutants can enter a lake from both point and nonpoint sources. Point sources are defined as all wastewater effluent discharges within a watershed. All other pollutant sources within a watershed are classified as nonpoint sources. Nonpoint sources can contribute pollutants to a lake through inflow from tributaries, direct runoff, direct precipitation on the lake surface, or through internal loading via lake sediments and groundwater inputs. Both natural events, such as precipitation and runoff, and human activities, including agriculture, silviculture, septic systems, and construction, can contribute pollutants to the lake system. Nonpoint sources can be difficult to quantify but are important because they often constitute the major source of pollutants to lakes.

Nonpoint source pollutant loadings for lakes (including reservoirs) can be assessed through a lake and stream monitoring program or by the Unit Areal Loading (UAL) approach (U.S. EPA, 1980). The monitoring approach requires the acquisition of both streamflow and water quality data for inlet (inflowing) streams during dry and wet weather periods. The UAL approach is based on the fact that different land use types contribute different quantities of pollutants through runoff.

The Unit Areal Loading (UAL) approach has been widely accepted as a method for estimating both nutrient and sediment loadings to lakes where little or no stream monitoring data have been collected. In this investigation, the UAL approach was used to estimate nonpoint phosphorus, nitrogen, and sediment loadings to Upper Echo Lake from its surrounding watershed area. In addition to the UAL approach, the phosphorus loading to the lake was also determined by using empirical phosphorus models. Comparisons of these two approaches are discussed in detail in Section 4.4 of the report.

4.2 Hydrologic Characteristics of Upper Echo Lake

The amount of water entering Upper Echo Lake was estimated by using a stream discharge to drainage area ratio for a nearby stream monitoring station. The nearest stream gaging station with continuous discharge measurements is located on Rahway River near Springfield, New Jersey (USGS Station No. 01394500).

The years of record, the drainage area, and the mean annual cfsm value for the above USGS stream station is presented in Table 4.1. By multiplying the mean annual cfsm value for the USGS Station by the Upper Echo Lake watershed area, it is estimated that the average discharge of water to Upper Echo Lake is 2.64 cubic feet per second (cfs) or 1.7 million gallons per day (MGD).

Based on the estimated discharge rate to Upper Echo Lake and its estimated volume, Upper Echo Lake has a hydraulic residence time of 3.6 days or 0.01 years. The inverse of the hydraulic residence time is the lake's flushing rate. Therefore, the water volume in Upper Echo Lake is flushed 100 times during an average year.

Table 4.1 Hydrologic Information for Rahway River near Springfield, New Jersey					
USGS Station No.					
01394500	1938-1996	25.5	1.17		

Source: USGS. Water Resources Data, New Jersey. Surface-Water Discharge and Surface-

Water-Quality Records.

4.3 Nutrient and Sediments Loading Estimates Using the UAL Approach

The annual loading of phosphorus, nitrogen, and suspended solids to Upper Echo Lake was estimated by selecting the most applicable export coefficients as shown in Table 4.2. These export coefficients were selected based on watershed geography, topography (slope), soil characteristics, and precipitation characteristics (frequency, duration, intensity, and quantity). In Table 4.2, the export coefficients for total phosphorus, total nitrogen, and total suspended solids are represented by the mean values for various land uses as reported by the U.S. Environmental Protection Agency (1980).

Table 4.2 Export Coefficients for Total Phosphorus, Total Nitrogen, and Total Suspended Solids					
	Range of Export Coefficients (lb/ac/yr)				
Land Use	Total Total Nitrogen Total Suspended Solids				
Parkland	0.22	1.42	357		
Forested	0.04	0.41	223		

Urban (Residential)	0.58	3.93	1427
Urban (Commercial)	2.23	14.97	1427

The annual total phosphorus, total nitrogen, and total suspended solids loadings to Upper Echo Lake were estimated using the export coefficients in Table 4.2 and the land use data presented in Section 2.4.4. These loading values are presented in Table 4.3, along with the estimated percentage of phosphorus, nitrogen, and suspended solids (sediments) contributed by each land use and by direct precipitation.

Table 4.3 Annual Reservoir Loadings of Total Phosphorus, Total Nitrogen, and Total Suspended Solids for Upper Echo Lake					
	Annual Load (lb/yr)				
Land Use	Total Total Nitrogen Total Suspended Solids				
Parkland	79.2 (12.3 %)	511.2 (11.6 %)	128,520 (8.5 %)		
Forested	5.9 (0.9%)	60.3 (1.4 %)	32,781 (2.2 %)		
Urban (Residential)	542.5 (83.7%)	3,676.1 (83.7%)	1,334,816 (88.5 %)		
Urban (Commercial)	17.8 (2.7%)	119.8 (2.7 %)	11,416 (0.7 %)		
Direct Precipitation	2.8 (0.4%) 22.6 (0.6 %) 319 (0.1 %)				
Total	648.2	4,390.0	1,507,852		

Based on the selected export coefficients and land use data, residential areas contribute the highest phosphorus, nitrogen and total suspended solids to the lake. Therefore, based on the pollutant budget, watershed restoration alternatives should focus on reducing pollutants from residential areas.

4.4 Phosphorus Loading Estimate by Using Empirical Models

In addition to the UAL approach, the annual total phosphorus loading to Upper Echo Lake was determined by using empirical models. Based on the lake water quality data collected during this study, phosphorus was identified as the "limiting" nutrient in Upper Echo Lake. Therefore, it is phosphorus that will most likely control the overall degree of eutrophication in the lake. If lake phosphorus concentrations were to decrease, the overall water quality in Upper Echo Lake would be expected to improve and vice versa.

Simply stated, the amount of phosphorus in the lake is a function of the following: (1) the amount of phosphorus flowing into the lake, (2) the amount of phosphorus flowing out of the lake, and (3) the amount of phosphorus settling to the bottom of the lake. This simple input-output principle has been used to develop a large number of models to predict the lake phosphorus concentrations if phosphorus inputs (phosphorus loadings) and watershed hydrologic characteristics are determined. The major difference between these models lies in the method of calculating their sedimentation term. Since it is not practical to measure phosphorus sedimentation directly, it must be estimated empirically based on a lake's morphometric and hydrologic characteristics.

All lake phosphorus models are based on two assumptions. The first assumption is that the lake behaves as a continuously stirred reactor. In other words, the phosphorus concentrations in the lake are uniform throughout the entire lake. Since this is seldom true in actual lake systems, it is necessary to sample a number of locations and different strata to estimate the true lake phosphorus content. The second assumption is that the lake is in a steady state condition, meaning phosphorous concentrations do not change over time. In order to incorporate this assumption, it is important to sample a lake at different times of the year to account for seasonal variations in total phosphorus concentrations.

These empirical models are most commonly used in lake management to predict the response of an existing lake to a change in its phosphorus load. In these cases, lake managers have the advantage of being able to compare the actual lake phosphorus concentration to the predicted concentration during the model evaluation process. The model selected is then used to predict the impact of changing the phosphorus load.

In this report, the mean total phosphorus concentration in the lake along with the physical characteristics of the lake were used to select the most appropriate phosphorus loading model for Upper Echo Lake. Next, the selected model was rearranged in order to determine the phosphorus loading. Finally, the model was used to determine the phosphorus loading reduction that would be necessary in order for the lake to attain a mesotrophic classification. Based on empirical modeling, the phosphorus loading to Upper Echo Lake is approximately 1338 lb/year.

5.0 Identification of Problem Areas

As part of the Upper Echo Lake Study, a watershed evaluation was performed to identify nonpoint source pollution problem areas within the Upper Echo Lake watershed. Several types of nonpoint source pollution problems were observed in the watershed.

5.1 Shoreline Erosion

Portions of the shoreline of Upper Echo Lake are experiencing excessive erosion problems. Shoreline erosion problem areas are shown in Figure 5.1. The shoreline erosion problem areas are aggravated by the waterfowl populations that walk up and down the banks to enter and exit the lake.

5.2 Streambank Erosion

Streambank erosion is also a problem at Upper Echo Lake. Streambank erosion problem areas are shown on Figure 5.1. Eroded sediment from streambanks is carried into Upper Echo Lake during storm events, and the sediment eventually settles to the bottom of the lake.

5.3 Waterfowl

Excessive numbers of waterfowl can create major water quality problems for lakes. The large numbers of waterfowl, mainly Canada geese and gulls, aggravate shoreline erosion problems by walking up and down the lake banks. The waterfowl droppings are also a problem and are a direct source of phosphorus, nitrogen, and bacteria to the lake. The large amount of waterfowl droppings around the lake is a significant problem at Upper Echo Lake.

5.4 Urban Stormwater Management

Based on our field investigations, it is apparent that stormwater runoff from impervious areas, such as parking lots and roads, enters the storm sewers and streams untreated. This untreated urban stormwater is a significant source of nutrients and sediments to Upper Echo Lake.

5.5 Lake Sedimentation

Excessive amounts of sediments have accumulated in Upper Echo Lake. Based on field observations, it is evident that the lake is filling up with sediments to a point where islands of sediments are beginning to form. If left alone, these islands would continue to develop, and vegetation would begin to grow in these areas.

Figure 5.1 Nonpoint Source Pollution Problem Area Map	
Upper Echo Lake Watershed Management Plan	Page 39

6.0 Recommended Management Plan

In developing a recommended management plan for Upper Echo Lake, both in-lake management alternatives and watershed management alternatives were evaluated. The first priority in all management programs is to determine whether watershed management practices can be implemented to reduce the pollutants entering the lake. Because nonpoint source pollutants account for all of the nutrient and sediment loadings to Upper Echo Lake, it is critical that lake restoration focuses on watershed controls in addition to in-lake restoration techniques.

Recommended in-lake restoration alternatives for Upper Echo Lake include lake dredging, possible lake aeration after dredging is completed, and batch alum treatment. Watershed management practices that are recommended for Upper Echo Lake include watershed investigations, shoreline stabilization, streambank stabilization, waterfowl control, urban stormwater management, riparian corridor management, and homeowner practices. In addition, a public education program, water quality monitoring program, and institutional approaches are recommended.

During the development of the watershed management plan, the following criteria were used to evaluate the potential management alternatives:

Effectiveness: how well a specific management practice meets its goal

Longevity: reflects the duration of treatment effectiveness

Confidence: refers to the number and quality of reports and

studies supporting the effectiveness rating given to a

specific treatment

Applicability: refers to whether or not the treatment directly affects the

cause of the problem and whether it is suitable for the

region in which it is considered for application

Potential for an evaluation should be made to ensure that a proposed

Negative management practice does not cause a negative

Impacts: impact on the lake ecosystem

Capital Costs: standard approaches should be used to evaluate

the cost-effectiveness of various alternatives

Operation and these costs should be evaluated to help determine

Maintenance the cost-effectiveness of each management

Costs: alternative

The recommended management plan for Upper Echo Lake is based upon the following: (1) lake and stream water quality data, (2) watershed tours, (3) estimated pollutant budgets, and (4) the goals as established by the Union County Waterways Team.

6.1 In-Lake Treatment

6.1.1 Lake Dredging

The physical removal of lake sediments can be used to achieve one or more objectives and is often referred to as the "ultimate face-lift". Overall, the costs for dredging are high, but the benefits are long-term, as long as control measures are implemented to minimize the amount of sediment entering the lake. The last time Upper Echo Lake was dredged was in 1992.

Upper Echo Lake contains approximately 43,200 cubic yards of unconsolidated sediment that should be removed by dredging. Upper Echo Lake should be mechanically dredged, and the sediments should be delivered to an approved disposal site.

Based on the sediment chemistry data, sediments in Upper Echo Lake are contaminated. Potential disposal areas for contaminated sediments include hazardous waste landfills and available non-residential land. County owned parkland may be acceptable for sediment disposal, but site remediation techniques such as capping the sediments may be required. Previous dredging projects used a disposal site within the park which may still have sufficient capacity for this project. The DEP has indicated that they will consider disposal sites for contaminated sediments on a case by case basis. Currently, DEP has no specific guidelines for the disposal of contaminated sediments. Finding an acceptable disposal site for the sediments may be difficult, but according to DEP personnel, it is not impossible.

A dredging feasibility study should be performed before detailed dredging design and permitting begins. The main work elements of the dredging feasibility study should include the following:

- 1. Attend a pre-application meeting with the DEP to discuss the project, to determine what permits will be required for this specific project, and to discuss potential disposal areas. A preapplication meeting is required by the DEP for dredging projects.
- Identify a suitable disposal area for the contaminated sediments.
 Suitable areas may include non-residential properties, including County property or hazardous waste landfills.

3. Prepare a dredging feasibility report for submission to the County. Based on information provided in this report, Union County can determine if dredging Upper Echo Lake is feasible.

The dredging feasibility study should also include an evaluation of beneficial soil reuse and reclamation of the contaminated sediments. This may be a difficult task due to the high concentration of semi-volatile compounds in the sediments.

6.1.2 Lake Aeration

Aeration has been widely used as a restoration measure for lakes where summer hypolimnetic oxygen depletion and/or winter-kill are of major concern. Aeration can be divided into two categories: those methods which destratify the lake water column and circulate the entire lake, and those methods which aerate the hypolimnion (deep water layer) without destratifying the lake. Both methods are based on the principle that if you increase the dissolved oxygen concentration in a lake, it will provide additional habitat for fish while decreasing the release of phosphorus from the sediments that can occur under anoxic (low dissolved oxygen) conditions.

Since the lake is well oxygenated except for a very small area near the bottom of the lake, a hypolimnetic aeration system would not be appropriate for Upper Echo Lake. A destratification aeration system would keep all the water aerated and cause the water column to circulate. This type of aeration system may be appropriate for Upper Echo Lake. However, aeration should only be considered for Upper Echo Lake after dredging occurs. After dredging is completed, aeration should be reevaluated. If the water column of the lake continues to be well oxygenated after dredging, aeration may not be necessary, unless it is desired for aesthetic purposes.

6.1.3 Chemical Treatment

Chemical treatment of the lake to control algae and macrophyte growth is often used as a band-aid approach to control undesirable plant growth in a lake. Chemical algicides are costly, must be continuously added to the lake, and can cause a buildup of undesirable chemical compounds in the lake. Alternative, long-term methods of improving water quality (i.e. dredging, nonpoint source pollution BMPs, shoreline stabilization) are environmentally responsible ways to avoid the use of potentially harmful chemicals.

6.1.4 Batch Alum Treatment

Batch alum treatment involves adding aluminum sulfate (alum) to the water column. This process is also referred to as phosphorus precipitation. Batch alum treatment is most applicable to shallow or otherwise unstratified lakes, such as Upper Echo Lake. The advantage to batch alum treatment is that dissolved and particulate phosphorus (including

algal cells) are removed via settling from the lake, resulting in an immediate and dramatic improvement in lake trophic parameters. The disadvantage to batch alum treatment is that much of the phosphorus-binding capacity of the aluminum may be used up prior to its reaching the sediments. Redistribution of the aluminum floc by wind and water currents may occur prior to settling, resulting in an incomplete bottom coverage. For these reasons, long-term control of sediment release can be greatly diminished.

Prior to recommending the use of batch alum treatment for Green Brook Lagoon, special jar testing of the lagoon water is required to determine dosages and to evaluate the impact of the alum on the pH of the lagoon water. The cost for the additional testing and evaluation would be approximately \$5,000. Implementation cost would be dependent upon dosage, but would be relatively inexpensive due to the size of the lagoon.

6.2 Watershed Controls

6.2.1 Establish Existing Conditions - Watershed Investigations

As part of this study, limited watershed investigations were conducted to identify specific nonpoint source pollution problem areas. General types of problems in the watershed were identified and specific streambank and shoreline erosion problem areas were identified. A more detailed watershed inventory is necessary to identify specific problem areas throughout the Upper Echo Lake watershed.

Since much of the watershed is already developed and since it was developed without the benefit of a comprehensive management plan, there are probably many existing areas that contribute to excessive stormwater runoff and soil erosion. These problem areas should be identified.

Areas to be investigated include, but should not be limited to, streambanks, culverts, roadways, roadway stream crossings, storm drainage pipes, and parking lots. Areas of excessive stormwater runoff and soil erosion should be investigated for all existing land uses including commercial, industrial, public, residential, and institutional.

Once these nonpoint source problem areas have been identified, they should be prioritized and analyzed for possible retrofit opportunities. Examples of potential retrofit opportunities include (Schueler, 1995):

- 1. Retrofit existing older stormwater management facilities.
- 2. Construct new stormwater controls at upstream end of road culverts.
- 3. Construct new stormwater controls at storm drainage pipe outfalls.

- 4. Construct small in-stream practices in open channels.
- 4. Construct on-site measures at the edges of large parking areas.
- 5. Construct new stormwater controls within highway rights-of-way.

Retrofit controls, or best management practices (BMPs) can include a large variety of measures including small detention areas, wet ponds, constructed wetlands, small pocket wetlands, sand filters, peat filters and bioretention systems. In some cases, retrofitting can consist of simple measures such as erosion control, soil stabilization, or stormwater diversion. Some nonpoint source problems can be eliminated by changing existing maintenance and operational procedures. For example, fertilization of lawns and golf courses could be modified to reduce nutrient runoff. Mowing of public areas could be modified to develop denser, taller, more natural vegetation, resulting in better control of stormwater runoff and increased removal of nutrients.

According to Thomas Schueler, Director of the Center for Watershed Protection (1995), elements to consider in stormwater retrofitting include the following:

- ! Ensure that retrofit site has adequate construction and maintenance access and sufficient construction staging area
- ! Verify existing utility locations, assess likelihood for conflicts, avoidance or relocation potential
- ! Identify existing natural resources and estimate sensitivity, avoid and minimize impacts where possible, assess likelihood for conflicts, and permit acquisition complications
- ! Identify adjacent land uses; select BMPs which will be compatible with nearby properties
- ! Look for opportunities to combine projects, such as combining stream stabilization and habitat restoration with retrofitting in a complementary manner
- ! Assess the difficulty of obtaining permits and identify necessary agencies to contact.
- ! Define project purposes (i.e., is the retrofit intended to help stabilize the hydrologic regime in terms of quantity controls or is the retrofit more directed at pollutant removal in terms of quality controls?)

The watershed investigations should be coordinated by Union County. Initial investigations can be performed by volunteers under the direction of a professional. The prioritization of nonpoint source problem areas and the evaluation of retrofit opportunities, however, should be performed by professionals.

6.2.2 Shoreline Stabilization and Streambank Stabilization

Soil erosion occurring along steep slopes, streambanks, and lake shoreline areas can contribute large quantities of nutrient-laden sediments to lakes. Land areas exhibiting high levels of soil erosion are commonly referred to as critical areas. Generally, soil erosion from critical areas will continue to occur at accelerated rates until these areas are properly stabilized. Excessive loadings of nutrient-laden sediments to lakes will result in increased levels of lake eutrophication.

Critical areas in a watershed may be stabilized using conventional methods, bioengineering methods, or a combination of both. Conventional methods such as rip-rap and gabions are very effective in controlling soil erosion, but they can be expensive to implement and do not always fit into the natural environment. Bioengineering methods consist of planted vegetation used separately or in conjunction with conventional methods to control soil erosion. Some highly effective bioengineering methods are live stakes, live fascine, brush layering, branchpacking, live gully repair, live cribwalls, vegetated rock gabions, vegetated rock walls, and vegetated rip-rap.

In the Upper Echo Lake watershed, high levels of soil erosion are occurring along steep slopes, streambanks, and lake shoreline areas as shown in Figure 5.1.

Severely eroded areas along the lake shoreline should be stabilized. The shoreline between the park boathouse/refectory and the dam is a heavy traffic area and should be stabilized with structural measures such as gabions or riprap to allow access to the lake and at the same time prevent further shoreline erosion. Erosion control matting may be used in the area; however, the vegetation immediately adjacent to the lake can not be mowed. A one to two foot unmowed buffer strip along the lake is needed to ensure proper erosion control. The vegetation in this area can consist of desirable and aesthetically pleasing vegetation such as blue flag iris, cardinal flower and rushes immediately along the water edge. Further away from the water (one to three feet from the water's edge) wildflowers can be planted. This type of vegetation will provide the required erosion protection and will attract wildlife such as hummingbirds and butterflies. The key element in this type of stabilization is that an unmowed area along the lake is necessary.

The shoreline between the lake inlet and the park boathouse/refectory should be stabilized with bioengineering techniques including coir fiber bundles and selected vegetation to provide

a natural setting in this area and to enhance wildlife habitat. Landscaping with vegetation and woody shrubs to control geese populations is encouraged in this area.

Severely eroded streambanks of the inlet streams should be stabilized. Approximately 250 linear feet of streambank along the smaller inlet stream to Upper Echo Lake is eroded and should be stabilized with bioengineering techniques. Approximately 2600 linear feet of streambank along the larger tributary of Upper Echo Lake is eroded and should be stabilized with a combination of bioengineering techniques and structural methods.

6.2.3 Waterfowl Control

Canada geese populations at Upper Echo Lake are excessive and should be controlled. Geese droppings are a significant and direct source of phosphorus, nitrogen and bacteria to Upper Echo Lake. Geese populations should be controlled by landscaping, egg inactivation, chemical deterrents, scare tactics, and culling during summer molt. Park visitors should be discouraged from feeding the geese and other waterfowl. Signs should be posted at strategic locations in the park to inform people about not feeding the waterfowl. An ordinance prohibiting feeding and subsequent enforcement is recommended.

A few facts that are important to note regarding the resident Canada geese population at the park include:

- ! Their life expectancy is very long in comparison to most bird species.
- ! The move-in rate by new members of the population is not well documented; however, it is believed to be quite high.
- ! There are few natural predatory species for the geese. The populations of the predatory species which do exist have been virtually eliminated in many areas due to intense urban development.
- ! Hunting is nearly impossible due to intense urban development so it no longer serves as a population check for the geese.

There are two basic solutions to the problem: on-site management techniques and removal of the geese from the site. These two solutions may be integrated to form a more effective geese control management plan.

Removal is a guaranteed option for eliminating the geese population. However, this is the most costly method and requires substantial permitting which takes a great deal of time and added expense. Also, there is no guarantee that permit application (and all included terms)

will be approved by the regulatory agencies. Removal is most easily conducted during molting when the geese are unable to fly and may be driven to a specified fenced-in area for capture. A major problem in removal and relocation of geese is that there are very few areas left to take the geese, since their presence is so undesirable. Presently, any geese captured under permit in Union County are destroyed and their edible parts are donated to local food banks. This procedure is very costly and in most cases is only implemented in the most serious situations.

On-site management of the geese is the other basic option for controlling the populations of resident Canada geese at a given location. Several on-site management techniques have been developed, tested, and found successful by the USDA, and are described below.

Controlled Landscaping Practices

Controlled landscaping practices and physical barriers will help deter the geese from residing in many areas. Studies have found that the geese do not feed in areas where the grass has been allowed to grow naturally. Also, preventing easy access to and from bodies of water greatly reduces the number of escape routes for the geese and therefore, significantly decreases their level of security. This may be accomplished by allowing emergent wetland plants and shoreline vegetation such as shrubs and grasses to grow, or by erecting physical barriers such as snow fences. It is important to note that the use of controlled landscaping practices and physical barriers may not be acceptable for certain land uses where open space and access to waterbodies is essential or desirable.

Egg Inactivation

Egg destruction has been found successful in preventing the addition of new, young Canada geese into the local population. Geese are capable of laying eggs for an approximated 28 days. However, the gestation period is greater than 28 days. Therefore, by the time that the female realizes that the eggs will never hatch, she is no longer capable of producing another clutch during that season. The eggs may be inactivated by several methods, including shaking, puncturing, replacing eggs with plastic substitutes, or coating the eggs with oil. The eggs must appear to be intact so that the female will not realize their impotency and lay more eggs.

Visual Deterrents

Visual deterrents such as special filaments, balloons, and scarecrows may be useful in many areas where the geese like to congregate. The disadvantage of visual deterrents is that in many cases they are unsightly to humans, they are not acceptable in every land-use, and they may lose their effectiveness as the geese become conditioned to their presence.

Chemical Deterrents

Chemical deterrents have also been developed by certain companies. These chemicals are applied directly to the vegetation in the areas where the geese feed and congregate, causing the geese to feel either discomfort or nausea. The use of certain visual deterrents (i.e. paint) in conjunction with the chemical deterrents may condition the geese to associate the visual

deterrent with the discomfort or nausea. Therefore, over time, only the visual deterrent may be necessary to control the geese and the use of chemical deterrents may either be reduced or eliminated. The disadvantages of this method of controlling geese populations are that the chemical deterrents need to be applied many times during the season, and the cost is very high.

Scare Tactics

Scare tactics such as the use of trained dogs, manually chasing geese from areas of congregation, and the use of explosive charges and other loud devices may be effective in driving the geese from a given area. Such methods may not be appropriate or safe, depending on the surrounding land use. And in many cases, the geese may become conditioned to and very tolerant of these scare tactics.

6.2.4 Urban Stormwater Management

Over the past ten years, a number of stormwater best management practices have been developed in order to reduce the adverse water quality impacts associated with urbanization. Overall, stormwater control measures serve two distinct functions: (1) reproduce predevelopment hydrologic conditions, and (2) provide pollutant removal capabilities. Historically, stormwater management has focused on reducing the frequency and severity of downstream flooding by reducing the peak discharge from post-developed sites. More recently, stormwater management has been redefined to include the removal of pollutants, thereby improving and protecting the quality of downstream waters.

Below is a list of stormwater management practices that were evaluated for urban areas in the Upper Echo Lake watershed area. In developed areas, stormwater management should primarily focus on urban stormwater controls such as sand filters, water quality inlets, and infiltration structures. These stormwater controls do not require vast areas of land, and therefore can be integrated into existing urban settings.

Urban Stormwater Controls

- 1. Sand Filters
- Water Quality Inlets
- 3. Infiltration Trenches
- 4. Bioretention Systems
- 5. Buffer Strips (Filter Strips)

In areas of future development or redevelopment, stormwater management controls such as infiltration basins, extended detention basins, constructed wetlands, and buffer strips, should be constructed or implemented. These stormwater control measures typically require larger tracts of land and therefore should be incorporated or designed as part of the land development planning process.

Other options for improving the water quality of stormwater runoff include:

- 1. Union County and local municipalities should evaluate street sweeping schedules. Increased street sweeping is recommended, especially in the spring and summer months.
- 2. Stormwater catch basins should be cleaned after major storm events or at least once every three months. Cooperation between Union County, the local municipalities, and the New Jersey Department of Transportation is recommended for this task.
- 3. Although most of the watershed is developed, every opportunity to improve stormwater quality should be taken. For example, if a commercial establishment changes ownership, and the new owner needs approvals from the local municipality, local ordinances should be in place to require improving stormwater runoff quality from the site before approvals are granted. Possible stormwater quality treatment systems that could be installed on a developed property include sand filters, peat filters, or bioretention systems. The purpose of these systems is to treat stormwater runoff from parking lots and roads. These systems are installed to treat the first 0.5 inches of stormwater runoff, which is commonly called the "first flush."
- 4. Existing homeowners and business owners should be encouraged to direct roof runoff to dry pits or rain barrels to reduce the amount of stormwater that enters the storm sewer system. Using a rain barrel or cistern gives the homeowner the advantage of water use reduction by storing rain water to water gardens or lawns during dry periods.

6.2.5 Riparian Corridor Management

Two tributaries enter Upper Echo Lake. A large portion of these tributaries are piped, underground systems. However, there are sections of the tributaries that are open, natural channels. These stream corridor areas should be preserved. Since these sections of the streams are located within the Upper Echo Lake Park, Union County should maintain the stream corridors in their present condition. Eroded areas of the streambanks should be stabilized as described above, and a 75-foot buffer should be maintained along the entire stream channel. Willows and other trees should be planted along the smaller inlet stream to stabilize the soil, intercept and treat stormwater runoff, modify stream temperature, and provide valuable habitat for wildlife.

6.2.6 Homeowner Practices

Homeowner practices are important since most of the nutrients and sediments that enter Upper Echo Lake originate from residential land within the watershed. Several howeowner practices are listed below. These practices can be implemented as part of a public education program.

- 1. Lawn fertilizer can be a significant source of nutrients to lakes, especially in suburban areas where nice green lawns are desirable. A fact sheet on the importance of limiting lawn fertilization should be prepared and distributed to homeowners in the watershed. This task could be facilitated through the public education program described below or by an "extra" in the local newspaper. Fact sheets could be posted at the park and possibly at local businesses.
- 2. Leaf management is also important in reducing nonpoint source pollution in a developed watershed. The existing leaf management program should be evaluated to determine if there are ways to improve the program so that leaves do not end up in the street for a long period of time. If leaves are left in the street too long, nutrients leach from the leaves and are carried into the storm sewers and eventually into the lake with stormwater runoff. Bagging leaves in biodegradable bags is one possibility for improving the leaf management program.
- 3. Homeowners should be informed that if they dump household chemicals and other substances into storm sewers, these substances will end up in the lake. Stenciling should be painted on storm inlets to educate homeowners that anything that goes down the storm sewer eventually drains directly into the lake.
- 4. Homeowners should be encouraged to wash cars and trucks on grassy areas, if possible, or use a commercial car wash. This practice will reduce the amount of phosphorus and detergent that runs down the driveway into a nearby storm sewer and eventually into Upper Echo Lake.

6.3 Other Lake and Watershed Management Recommendations

Other recommendations to help improve the water quality of Upper Echo Lake include a public education program, a water quality monitoring program, and institutional approaches.

6.3.1 Public Education Program

The U.S. Environmental Protection Agency (EPA) actively encourages the development of environmental education programs by providing helpful literature, suggestions and funding sources. The U.S. EPA has funded education programs, such as the program developed for Lake Wallenpaupack (F. X. Browne, Inc., 1994), through its 314 Clean Lakes Program, its 319 Nonpoint Source Program and its Environmental Education Program.

Union County has developed and is continuing to implement an environmental education program throughout the County. The County's environmental education program should be integrated into the Upper Echo Lake watershed. The environmental education program for Upper Echo Lake should include the following elements:

- 1. Develop and distribute nonpoint source brochure,
- 2. Develop a watershed management program for presentation to local schools,
- 3. Develop and install a kiosk at Upper Echo Lake,
- 4. Write fact sheet on watershed management for distribution at the kiosk and at park events, and
- 5. The satellite operation of Trailside Nature and Science Center being developed by the County for location in Warinanco Park should include staffing to conduct watershed management education programs.

6.3.2 Water Quality Monitoring Program

A limited water quality monitoring program should be implemented after dredging has been completed to document water quality improvements. Yearly monitoring of selected parameters (i.e. total phosphorus, chlorophyll \underline{a} , Secchi disk transparency and dissolved oxygen/temperature profiles) should be conducted to document water quality changes in the lake. Sample collection could be tied into the Trailside curriculum mentioned above.

6.3.3 Fish Stocking

A survey of fish species diversity should be performed approximately two years after the lake and watershed management recommendations have been implemented. Determining the number of fish and the different species present is critical to the development of a fish stocking program in order to ensure the best survival rate of the introduced fish.

6.3.4 Institutional Practices

Union County Waterways Team

The Union County Waterways Team should work closely with Township officials to improve the water quality in Upper Echo Lake. Recommended tasks that should be performed by the Waterways Team with the assistance of Township officials are as follows:

- 1. To evaluate existing subdivision ordinances, erosion and sedimentation control ordinances, and other ordinances for their applicability to the Upper Echo Lake watershed area.
- 2. To determine if any of the above ordinances require revisions to further protect stream and lake water quality.
- 3. To assist in the coordination of all lake and watershed management activities.
- 4. To establish a "Watershed Watch" program to ensure that erosion and sedimentation controls are properly installed and maintained during and after construction activities, and to watch for bank and stream erosion.
- 5. To communicate watershed problems including the lack of compliance with municipal ordinances to the proper authorities.
- 6. To assist in obtaining funds for the implementation of lake and watershed management best management practices.

Ordinances

The Union County Waterways Team, with the assistance of municipal officials, should evaluate the existing erosion and sedimentation control and stormwater control ordinances to ensure that these documents are effectively protecting the water quality in County streams and lakes. The Waterways Team, with the assistance of municipal officials, should also evaluate the applicability of lawn fertilization and waterfowl feeding ordinances for the Upper Echo Lake watershed.

In addition to the above, the Waterways Team also should establish a riparian corridor conservation ordinance to protect the water quality of streams and lakes in the county. The preservation of riparian stream corridors has many benefits including:

- 1. Floodplain Protection
- 2. Nonpoint Source/Stormwater Runoff Protection
- Habitat Protection

Existing forested buffers along stream corridors should be maintained. Reforestation should be performed where forest buffers no longer exist. Forest buffers stabilize the soil, intercept and treat stormwater runoff, modify stream temperature, and provide valuable habitat for wildlife.

6.4 Implementation Costs

The proposed budget for the various elements of the Upper Echo Lake Restoration Project is shown in Table 6.1. These costs include engineering design, permitting, construction and construction observation costs. The cost for dredging Upper Echo Lake is difficult to estimate since the sediments are contaminated. However, assuming that an acceptable disposal area can be found within 5 miles of the lake, and assuming that capping or covering the sediment is required, the estimated cost to dredge Upper Echo Lake could range from \$1,100,000 to \$1,400,000. This cost may increase if the sediment must be disposed of in a hazardous waste landfill.

6.5 Funding Sources

There are many state and federal programs that provide funding for lake and watershed management projects. The two primary funding sources for implementing the recommended management plan are the New Jersey Clean Lakes Program and the EPA's 319 Nonpoint Source Program. The Clean Lakes Program provides 50% funding to implement best management practices and public education programs. The 319 Nonpoint Source program provides funds for watershed management projects and public education programs. Union County has already received and is implementing a 319 grant to install streambank and shoreline stabilization measures and enhance their environmental education program.

6.6 Upper Echo Lake Restoration Project Schedule

The recommended management plan for Upper Echo Lake should be implemented in stages. In particular, watershed best management practices should be first implemented in the most critical areas. The dredging feasibility study can begin immediately so that a suitable sediment disposal area can be found as soon as possible. After watershed practices are installed and after the dredging feasibility study is complete, dredging design, permitting and construction can begin.

Table 6.1
Budget Summary for the Proposed
Upper Echo Lake Restoration Project

Task	Description	Estimated Costs*
1	Dredging Feasibility Study	\$10,000**
2	Dredging (Engineering, Permitting, and Construction)	\$1,400,000
2	Stormwater Control Measures	\$10,000 [^]
3	Streambank Stabilization	\$50,000
4	Shoreline Stabilization	\$30,000
5	Homeowner Practices	\$7,000 ^{^^}
5	Environmental Education	\$18,000
6	Water Quality Monitoring	\$6,000
7	Project Administration	\$5,000
8	Project Documentation and Final Report	\$8,000
Total \$1,544,000		

These costs are in 1997 dollars and are subject to change based on when and to what extent the management program is implemented.

The construction cost for lake dredging is estimated at \$1,100,000 - \$1,400,000 as described in Section 6.4. This cost for the feasibility study does not include the cost of any additional sediment analysis since these costs can not be determined until after the pre-application meeting with the DEP.

This cost is to implement operation and maintenance of existing facilities such as cleaning of inlets, etc, as described in Section 6.2.4. Depending upon the extent that the County implements this task, the cost could increase or decrease. This is an estimated annual cost.

This cost includes consulting fees to prepare information and County administration fees to disseminate information.

7.0 Environmental Evaluation

Since socio-economic and environmental impacts are part of the cost-effectiveness analysis for the restoration of Upper Echo Lake, many of these impacts were addressed during the evaluation of restoration alternatives. However, the impacts and their mitigative measures are formally documented below using the environmental evaluation checklist in the Clean Lakes Program Guidance Manual (U.S. EPA, 1980).

1. Will the project displace people?

No.

2. Will the project deface existing residences or residential areas?

No. Residential areas are not affected by the proposed plan.

3. Will the project be likely to lead to changes in established land use pattern or an increase in development pressure?

No.

4. Will the project adversely affect prime agricultural land or activities?

No.

5. Will the project adversely affect parkland, public land or scenic land?

Temporarily. During the lake sediment removal and shoreline stabilization portions of this project, sections of the parkland will be disturbed. Upon completion of lake dredging, the parkland will be regraded and revegetated to its original appearance. Construction equipment will be required for the construction of the shoreline and streambank stabilization measures.

6. Will the project adversely affect lands or structures of historic, architectural, archeological or cultural value?

No. In fact, it will restore the lake to the historic Olmsted design.

7. Will the project lead to a significant long-range increase in energy demands?

No.

8. Will the project adversely affect short-term or long-term ambient air quality?

No. The lake sediments are well oxygenated throughout the year and contain low levels of organic materials.

9. Will the project adversely affect short-term or long-term noise levels?

No.

10. If the project involves the use of in-lake chemical treatment, will it cause any short-term or long-term effects?

No chemical treatments are proposed for Upper Echo Lake as outlined in the Lake and Watershed Management Plan Section of this report.

11. Will the project be located in a floodplain?

Yes. Sediment removal activities will be temporarily employed in Upper Echo Lake.

12. Will structures be constructed in the floodplain?

Yes. Gabions may be used for shoreline stabilization along areas of the shoreline that receive heavy pedestrian traffic.

13. If the project involves physically modifying the lake shore, its bed, or its watershed, will the project cause any short or long-term adverse effects?

Yes. A portion of lake shoreline will be regraded and revegetated to reduce further soil erosion. The short-term adverse effect of the construction work required for the regrading of the shoreline will be minimal, and after a few months, the vegetation will be reestablished.

14. Will the project have a significant adverse effect on fish and wildlife, wetlands or other wildlife habitat?

Yes. Sediment removal will have short-term adverse impacts on the aquatic biota. However, within six months after dredging is complete, the benthic community is expected to return to normal.

15. Have all feasible alternatives to the project been considered in terms of environmental impacts, resource commitment, public interest and cost?

Yes.

16. Are there other measures not previously discussed which are necessary to mitigate adverse impacts resulting from the project?

There are no possible mitigation measures known at the present time which have not been discussed.

8.0	Public Participation
On from tl	a public meeting was held to present this Plan to the public. A copy of the transcript nis public meeting is provided in Appendix E.
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